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THE PLUCKING EXPERIMENTS AT BORBHETTA IN 1928

by

H. R. Cooper.

The effect of the season on the Borbhetta Plucking Plots. The 1928 tea season in North-East India was marked by a bad start, following a severe drought, and by a poor latter end, following cold and wet. August, September and early October produced good flushes, but the season on the whole was unfavourable compared to 1927.

The plots occupied by the Borbhetta plucking experiments were severely attacked by rim blight in the early part of 1928, by which growth on most of the plots was seriously delayed. The result of unfavourable weather conditions and blight attack was that the total crop from these plots was less in 1928 than in 1927 by about 7%.

The decrease in crop from the combined effect of the bad season and rim blight did not affect all parts of the area to the same degree, as is shown in the following table :—

TABLE I.

lbs. leaf per plot of 640 bushes.

Plot.	1927.	1928.	Seasonal loss or gain per cent.
148	1288	1329	3% gain
149	1367	1371	.....
150	1375	1260	8% loss
151	1423	1373	3½% loss
152	1428	1284	10% loss
153	1410	1284	9% loss
154	1427	1250	12½% loss
155	1547	1275	18% loss
Total ...	11265	10434	7% loss

From 1922 to 1926 the plots had always maintained practically the same relative position as in 1927. It was therefore very surprising to find that Plot 155 which had always been the best plot, became almost the worst in 1928; while Plot 148 which had always been the worst plot became almost the best in 1928. All lines in Plot 155, whatever the plucking, were very bad with rim blight; while all lines of Plot 148 remained relatively free.

The result is that the crops from certain plucking systems are unduly affected in 1928 by the geographical distribution of the lines under those treatments.

Thus the lines plucked at 4″ to the janam fall in plots which lose respectively 0, 8, 3½, and 9 per cent. and were therefore less affected by the season than the lines plucked over 3 leaves, then 2 leaves, then 1 leaf which fall into plots which lose respectively 0, 8, 10, and 17½ per cent. These are the two most extreme cases of undue influence of position on probable yield.

Similarly, of the sixteen lines plucked at 6″ and then to the janam, two lines fall into plot 148 which gains 3%, and three lines fall into plot 155 which loses 17½; while of the sixteen lines plucked at 6″ and then over 1 leaf, four lines fall into plot 148, and only one line into plot 155.

The geographical distribution of the lines in the plots would be expected to cause a seasonal loss of crop about 2% greater in the case of the lines plucked to the janam than in the case of the lines plucked over a big leaf. In actual fact the lines plucked at 6″ and then to janam lost 6% in 1928 compared to 1927, while the lines plucked at 6″ and then over a big leaf gave 4½% less in 1928 than in 1927. The apparent relative improvement of the lines plucked over a big leaf is therefore probably to be ascribed to the accident of the geographical position of the lines rather than to the good effect on the bush of the relatively lighter plucking in 1927.

Poorer agreement among the results from series under the same treatment is due to the same cause; as seen in Table II.

TABLE II.

Yields from series under the same teatment.

	1927.	1928.	Seasonal loss.
Plucked to 6″ and then to janam—			
Series 1	761	705	51 = 7%
„ 11	732	684	38 × 6%
„ 12	745	706	39 = 5%
„ 13	748	723	25 = 3%
Average	746	704	42 = 6%
Maximum difference from mean ...	15	20	
Plucked to 8″ and then to janam—			
Series 8	667	654	13 = 2%
„ 14	670	610	60 = 9%
„ 15	681	663	18 = 2½%
„ 16	667	638	29 = 4%
Average	671	641	30 = 4½%
Maximum difference from mean ...	10	31	

One of the four lines comprising each series 1, 11, 12, and 14 occurred in the very badly blighted plot 155, and this mainly accounts for the relatively large decreases in yield from these series, as compared to others under the same treatment.

The effect of the season, therefore, has been not only to reduce crop generally; but to reduce it unevenly over different parts of the experimental area, and so introduce a greater experimental error in 1928, than in 1927. In spite of this, the general trend of the large number of experiments brings out interesting and useful facts.

Complete details of the results obtained are shown in the following table for record :—

TABLE III.

Results of plucking experiments.

Series No.	lbs. leaf per 320 bushes all same plucking.		Plucking in 1927 & 1928.	Yields 1927. lbs. leaf from 320 bushes.			Mds pucca tea per acre.	Yields 1928. lbs. leaf per 320 bushes.			Mds. pucca tea per acre.
	1925.	1926.		To 6th Aug.	13th Aug. to end of season.	Total.		To 5th Aug.	12th Aug. to end of season.	Total.	
1	609	704	4″ to janam	275	480	755	14·79	243	523	766	15·01
2	602	699		277	484	761		205	500	705	
11	598	704	6″ do.	253 / 264 / 269 } 266	479 / 481 / 479 } 481	732 / 745 / 748 } 746	14·63	187 / 201 / 208 } 200	497 / 505 / 515 } 504	684 / 706 / 723 } 704	13·80
12	594	694									
13	605	701									
3	610	701	8″ do.	251	482	733	14·37	158	492	650	12·74
4	607	701	10″ do.	193	467	660	12·93	122	462	584	11·45
7	601	698	8″ then 1 leaf then janam	246	447	693	13·59	195	484	679	13·31
8	610	705		225	442	667		169	485	654	
14	609	705	6″ do.	221 / 237 / 216 } 225	449 / 444 / 451 } 446	670 / 681 / 667 } 671	13·15	145 / 166 / 158 } 159	465 / 497 / 480 } 482	610 / 663 / 635 } 641	12·65
15	595	701									
16	607	698									
9	613	707	8″ do.	220	452	672	13·17	98	453	551	10·80
5	600	697	6″ then 8″	193	457	650	12·74	133	485	618	12·05
6	602	696	4″ then 6″ then 8″	241	485	726	14·23	157	468	625	12·25
10	607	706	3 leaves then 2 leaves then 1 leaf then janam	272	425	704	13·80	170	397	567	11·11

DISCUSSION OF RESULTS.

Effect of Leaving Different Lengths of Initial Growth.

The most noteworthy feature of the results in 1928 is that the initial growth left made a great difference to the the crop obtained. Whereas in 1927 it made little difference to crop, whether 4″, 6″ or 8″, were left at the first tipping, in 1928 the more new growth allowed before tipping the smaller was the crop obtained.

System of plucking.	Mds. tea per acre.	
	1927.	1928.
4″ then to janam	14·79	15·01
6″ do.	14·63	13·80
8″ do.	14·37	12·74
10″ do.	12·93	11·45

It will be observed that in 1927 the difference in crop by leaving 4″, 6″, or 8″ was almost negligible. Bushes did not go *banjhi* till they had grown over 8″.

With the slow start of 1928, bushes began to go *banjhi* before they had reached 6″, and did not come away freely till August when growth generally became freer than in the previous year, until nearly the end of October.

In 1928 it will be observed that every extra 2″ of initial growth caused a loss of about 1.2 mds. of tea. A similar tendency is seen when a big leaf is left leaving the initial growth :—

System of plucking.	Mds. tea per acre.	
	1927.	1928.
4″ then 1 leaf, then janam	13·59	13·31
6″ do. do.	13·15	12·65
8″ do. do.	13·17	10·80

Here again the initial growth left made little difference to crop in 1927, and a big difference in 1928.

Effect of Leaving a Big Leaf over the Initial Growth.

Crop was, as in 1927, lost in all cases by leaving a big leaf over the initial growth before plucking to the janam.

				Loss due to leaving a big leaf mds. tea.
4″ to janam ...	15·01	4″ then 1 leaf then janam ...	13·31	1·70
6″ to janam ...	13·80	6″ do. do. ...	12·65	1·15
8″ to janam ...	12·74	8″ do. do. ...	10·80	1·94

Effect of other systems of leading growth after the original tipping

System of plucking.	Mds. tea per acre.	
	1927.	1928.
6″ then 8″	12·74	12·05
4″ then 6″, then 8″	14·23	12·25
3 leaves, then 2 leaves, then 1 leaf ...	13·80	11·11
and, for comparison—		
6″ to janam	14·63	13·80
6″ then 1 leaf, then janam	13·15	12·65

Comparing plucking at 6″ and then to 8″ with leaving a big leaf over 6″, it will be seen that the relative loss was even a little greater in 1928 than in 1927.

Referring to Table III, and comparing series 5, with the mean of series 8, 14, 15 and 16, it will be seen that all the loss was made in the early season, while waiting for the extra growth on the sides in both years.

The greater degree of sparing of the sides in 1927 has not yet resulted in such strengthening that it shows in crop in 1928.

The system of plucking to 4″, then to 6″ and then to 8″ has given very much less crop in 1928 than in 1927. Plucking heights, in both years, were lifted from 4″ to 6″ and

from 6″ to 8″, when the bushes had become flat. Owing to the slow early growth the dates of lifting were so much later in 1928 than in 1927 that the bushes were relatively much more lightly plucked. For the same reason the crop from the old system of conical plucking (3 leaves, 2 leaves, 1 leaf) was very much less in 1928 than in 1927. In 1928, most of the bushes were not being plucked to the janam till very close to the end of the season. In 1927 the late crop (after August 6th) was poorer than under any other system of plucking: in 1928 not only was the late crop poor, but the slow start produced a relatively small early crop also.

In the first two years of plucking it is very clear that the harder the plucking the greater the crop obtained.

From the evidence to-date it appears that there will be a much greater difference in favour of short initial growth in a year of slow start, than in a year of rapid early growth.

GENERAL.

In the first two years of plucking, it is very clear that the the initial tipping has been a substantial loss of crop.

It will be observed that in no case has reduced early crop from lighter plucking, led to any increase in crop in the latter part of the season. Nor has lighter plucking in 1927, led to any increase in crop in 1928. The increase in vigour of the bush from more sparing plucking, clearly takes some time before it is reflected in crop. Except at the time of rim-blight attack, which entirely disappears (whatever the plucking) by about the middle of July, the bushes under this experiment are generally very vigorous, and therefore may stand the strain of hard plucking longer than poorer bushes would.

The appearance of the very hard plucked bushes (4″ to janam for example) at the end of the season is now generally poor, and they pruned out on very thin wood, but this thin wood still shoots vigorously, while on the harder plucked bushes more shoots from low down reach the plucking surface.

If still remains to be seen how long the bushes will stand this forcing without deterioration.

The slower start, in 1928, rendered the accurate application of the particular systems of plucking much easier than in 1927. There was very much less tendency to run away; distances between leaves, and between the new janam and the last plucking were less, and there was less total growth at the end of the season in 1928 than in 1927, as shown in the following Table IV.

TABLE IV

Average total growth in inches above pruning level.

	1927.				1928.			
	Middle of bush.		Sides.		Middle of bush.		Sides.	
Series 1 4″ to janam ...	9·1		7·8		7·2		6·6	
„ 2	10·4	10·3	9·2	9·0	8·3	8·5	7·7	7·7
„ 11 6″ „ „ ...	10·4		9·1		8·6		7·7	
„ 12	9·9		9·0		8·3		7·6	
„ 13	10·0		8·8		8·7		7·9	
„ 3 8″ „ „ ...	11·0		9 7		9·6		8·4	
„ 4 10″ „ „ ...	13·0		12·1		12·8			
„ 7 4″ then 1 leaf, then janam	11·0		10·1		9·0		11·5	
							7·9	
„ 8	12·4	12·2	10·8	10·8	11·0	10·6	9·9	9·5
„ 14 6″ do. do.	11·6		10·6		10·2		9·1	
„ 15	12·2		10·7		10·9		9·6	
„ 16	12·6		11·0		10·4		9·3	
„ 9 8″ do. do.	13·0		11·1		11·6		10·8	
„ 5 6″ then 8″ ...	12·3		11·2		9·8		9·5	
„ 6 4″ then 6″, then 8″								
„ 10 3 Leaves, then 2	10·1		8·9		8·9		8·1	
leaves, then 1 leaf	17·0		10·0		15·1		9·6	

SKETCH MAP
part of
LAKHIMPUR

Scale 1 inch = 4 miles
0 5 10

Roads
District Boundary
Forest Reserve
Hills & Mountains
Tea gardens marked in red & approximate positions shown thus

N

ABOR HILLS
SADIYA FRONTIER TRACT
LAKHIMPUR
NORTH
BRAHMAPUTRA RIVER
DIBRU R.F.
DEHINGMUKH R.F.
JOKAI R.F.
JAIPUR R.F.
KAKOJAN R.F.
UPPER DIHING R.F.
NAGA HILLS TRIBAL TERRITORY
TIPAM HILLS
SIBSAGAR
SADIYA FRONTIER TRACT
LOHIT R.
Lali
Dihang
Dibang
Kundil
Sadiya
Senpura
Tenga Pani
Kolia pani
Buri suti
Laimakuri Saw mills
Dibru N.
Dangori
Noa Dehing
Dirak
Dum Duma N.
Moilajan
Dioru N.
Tingrai
Burhi Dihing
Tirap
Tirap R.
Dirok R.
Dihing
Disang R.
A.B.R.
D.S.R.
Saikhoa
Dhola
Hakalli
Pangri
Laina
Khobang
Talap
Daisajan
Tiphuk
Dangori
Tonganna
Kumsong
Burdubi
Bogpara
Budla Bela
Sukerating
Hansara
Tara
Dum Duma
Bisakupi
Rupai
Dhaimukhia
Deomulli
Dighaltarang
Baghjan
Pabhojan
Dhelakhat
Hilika
Hukanguri
Dheodam
Longsoal
Betjan
Gelapukhari
Limbuguri
Bazaltoli
Woodbine R.F.
Dinjan
Panitola
Nokroy
Kachujan
Makum
Raidang Samdang
Bara Hapjan
Chota Hapjan
Tinsukia
Hukapukhuri
Anandabad
Tengpani
Langkasi
Rajghurali
Boga pani
Boga Pani
Pengri
Khatangpani
Bordubi Rd.
Mankhusi
Jutlibari
Hugrijan
Hatigarh
Dirial
Tipling
Rajaali
Bazaloni
Powai
North Bank
Ledo
Targherita
Dirok
Namdang
Makum
Tarajan
Namsang
Nahorkatiya
Jaipur
Langrajan
Nahar katiya
Tinali
Tinkhang
Achabam
Umtara
Balimara
Hapjan Parbat
Namrup
Dili
Borhat
Sapekhati
Rajabari
Borham
Tekerai
Moran
Moran Hat
Pathalibam
Dikhari
Nahorani
Sepon
Khagrijan
Khowang
Bhaman
Lengrai
Phukanbari
Bakolajan
Romai
Singlijan
Rungliting
Jokai
Tamulbari
Bokel
Sessa
Wilton
Hatiali
Sealkati
Chabua
Maud
Pulonga
Dikom
Lahoal
Mohanbari
Nadua
Hazelbank
Thanai
Titadimaru
Nahortali
Ethelwold
Barbari
Chaulkhoa
Greenwood
Makalbari
Oaklands
Dhalejan
Kanjikhoa
Udalguri
Kharjan
Rohmoria
Nagaghuli
Dholla
Dangarh
Mohak
Chowkidinghi
Str.ghat
Biheating
Jamira
Barbarua
Khanikor
Mankata
Lepetkata
Ghurania
Medla
Boyle
Dewan
Sisi Saw Mills
Dihingmukh
Ramgangia
Rangagora
Mohanbigoali
Itakhuli
Deohal
Keyheng
Chola Tingrai
Tengpani
Langkasi
Rajghurali
Boga pani
Boga Pani
Pengri
Khatangpani
Bordubi Rd.
Mankhusi
Jutlibari
Hugrijan
Hatigarh
Dirial
Tipling
Rajaali
Bazaloni
Powai
North Bank
Ledo
Targherita
Dirok
Namdang
Makum
Tarajan
Namsang
Nahorkatiya
Jaipur
Langrajan
Nahar katiya
Tinali
Tinkhang
Achabam
Umtara
Balimara
Hapjan Parbat
Namrup
Dili
Borhat
Sapekhati
Rajabari
Borham
Tekerai
Moran
Moran Hat
Pathalibam
Dikhari
Nahorani
Sepon
Khagrijan
Khowang
Bhaman
Lengrai
Phukanbari
Bakolajan
Romai
Singlijan
Rungliting
Jokai
Tamulbari
Bokel
Sessa
Wilton
Hatiali
Sealkati
Chabua
Maud
Pulonga
Dikom
Lahoal
Mohanbari
Nadua
Hazelbank
Thanai
Titadimaru
Nahortali
Ethelwold
Barbari
Chaulkhoa
Greenwood
Makalbari
Oaklands
Dhalejan
Kanjikhoa
Udalguri
Kharjan
Rohmoria
Nagaghuli
Dholla
Dangarh
Mohak
Chowkidinghi
Str.ghat
Biheating
Jamira
Barbarua
Khanikor
Mankata
Lepetkata
Ghurania
Medla
Boyle
Dewan
Sisi Saw Mills
Dihingmukh

THE LAKHIMPUR DISTRICT.

Soil Survey.

by

C. R. Harler.

Geography and geology.

The district of Lakhimpur formerly occupied the whole of the country at the head of the Assam Valley, with its boundaries vaguely demarcated on three sides by the foothills of the Himalayas and Naga Hills. After the Abor trouble in 1911 the Sadiya Frontier Tract was formed, consisting of a broad stretch of land running from the hills to the plains and generally separating what is now Lakhimpur from the hills. The Frontier Tract, which extends in the north and east to the confines of Tibet and touches Burma on the south-east and south, is under the control of a Political Officer. On the south, Lakhimpur joins the Sibsagar division, and for a short distance marches with Naga Hill Territory. On the north of the Brahmaputra the division, where it does not meet the Frontier Tract, is bounded by the Abor Hills, the local name for that part of Himalayan range. For administrative purposes the district is divided into two sub-districts, Dibrugarh and North Lakhimpur on the south and north banks of the River (1).

The Lakhimpur district consists of a broad plain on either side of the Brahmaputra. To the south the hills rise only a few thousand feet above sea level, but to the north they extend to a continuous chain of snowy peaks. On the south of the River the plain is fairly high, and a broad belt of country along the foot hills is clothed in dense forest. In the centre of this area the country is cleared and cultivated under tea and rice. The drainage is carried on by *jans* and small rivers and there are few swamps or *bheels*.

(1) Allen, B.C., Assam District Gazetteers, Lakhimpur, Calcutta, 1905 (vol. 8). Friel, R., Supplement to vol. 8, Assam District Gazetteers, Shillong, 1916.

On the north bank of the Brahmaputra the country is much lower, *bheels* are common and during the monsoon the country side is inundated. This is a country of grass and high reeds, although towards Sadiya forest abounds.

Although Lakhimpur is surrounded on three sides by hills and mountains, almost the whole area is flat, level plain. An outlying spur of the Naga Hills stretches from the Disang River and near Jaipur, Margherita and Digboi there are a few hills. Although Dibrugarh is about 1,000 miles from the sea, by river its elevation is only 340 feet. Sadiya has an altitude of 440 feet.

The salient feature of Lakhimpur and, in fact, of the whole of the Assam Valley is the Brahmaputra. Hindu tradition describes this river as rising in the sacred pool at Brahmakund, about 50 miles east of Sadiya, but it has been shown that the Lohit, which flows east from Sadiya comes from the Rima Valley, where it is known as the Zayul Chu. The Dihang has long been supposed to be indentical with the Tsangpo of Tibet, and hence to be regarded as the main stream of the Brahmaputra. The explorations of Bailey and Morshead in 1913 from Assam *via* the Mishmi Hills to the head of the Tsangpo gorge practically proved this. The final gap of 30 miles in the course of the River was explored from the Tibetan side by Kingdom Ward in 1924 (2).

The Brahmaputra runs between sandy banks when it reaches the plains and oscillates in a wide strath, forming divergent channels which later rejoin the main stream. The stream is heavily laden with silt, although the fall being greater than six inches to the mile, much of the finer sediment is carried on. The smallest obstruction in the river is liable to form an almond shaped bank which, with the next flood, may be entirely deleted or grow to form a *chur* or island.

The principal tributaries of the Brahmaputra within the Lakhimpur division on the north bank are the Lohit, Dibang,

(2) Kingdon Ward, F., Exploration in South Eastern Tibet, *Geog. Jour.*, London, 1926 (vol. 67, No. 2).

Subansiri, the Ranganadi and Dikrang, but most of them are of little importance in the economy of the district. Some of these rivers enter the plains through gorges of singular beauty, the Subansiri being particularly notable in this respect.

The most important tributary on the south bank is the Burhi Dihing which rises in the Patkoi range, meanders past Margherita and Jaipur, thence to the Brahmaputra at Dihingmukh. The Noa Dihing, which is connected with the Burhi Dihing, flows into the Brahmaputra east of Sadiya. The country between these two rivers is drained by the Dibru, a small river receiving the Dum-Duma and Dangori.

Our knowledge of the geology of the Assam Valley is obtained from the papers issued at various times by the Geological Survey of India, giving accounts of work done in connection with the various coal areas and petroleum and auriferous occurrences in the province (3).

Generally speaking, the Upper Assam Valley runs north-east and south-west between two parallel mountain chains. Of these, the eastern Himalayas are formed of a massive chrystalline and metamorphic core with a comparatively narrow southern fringe of sedimentary rocks. The Patkoi range, or Naga Hills as it is called in Assam, has an apparent core of slates and sandstones of an indeterminate age, probably as young as Lower Tertiary, overlaid by an immense deposit of Upper Tertiary sandstone. The head of the Assam Valley is closed by the crystallines and metamorphics of the Miju Range (beyond Brahmakund) which lies across it at right angles to the two lateral ranges.

Before the formation of the Himalayan range the country now occupied by the Assam Valley was low lying land bordering on the sea which then existed where now is Tibet. This low land

(3) See particularly—

Maclaren, J. M., The Geology of Upper Assam, *Rec. Geol. Sur. Ind.*, Calcutta, 1904 (vol. 31, pt. 4).

Pascoe, E. H., The Petroleum occurrence of Assam and Bengal, *Mem. Geol. Sur. India*, Calcutta, 1914 (vol. 40, pt. 2).

was successively submerged and raised so that at one time it carried dense forests and at another was depressed and its vegetation covered by hundreds of feet of muds. The remains of this vegetation are now the coal measures of Assam, extending along the south of the valley from the Dihing to the Shillong plateau, although previously they probably extended across what is now the Assam Valley itself.

The muds and clays of the coal measures were now in turn buried beneath enormous gravel deposits brought down by the silt laden rivers of the north, the ancient representatives of the Subansiri, Tsangpo, Dibong and Lohit, which poured in from what is now Tibet, an area at that time being gradually raised above the sea. These gravel beds stretched along a plain the width of Burma, bound on the east by the Miju range. It appears that the major portion of the great land extending into the Bay of Bengal, now known as Burma, was laid down at this time with the spoils of the Tibetan highlands. The western limit of deposition at this period was probably somewhere in the region of the Shillong plateau.

The next great change in the physical history of this area consisted of an uplift in the earth's crust, unattended by any great disturbance of strata, resulting in the formation of the eastern Himalaya to the north and the Patkoi range to the south. That this upheaval was of a slow and quiet nature is evidenced by the limited folding of the strata.

The deflection of the Brahmaputra and kindred rivers from a southern course across Burma to a westerly one along the base of the Himalayas had taken place with the initial uplift of the Patkoi. While the Brahmaputra has no doubt considerably eroded the Tertiary sandstone along its course, the practically entire absence of these rocks from the Valley surface may be due to a depression of the floor which carried them below the level of erosion, leaving the Brahmaputra to fill up the valley with its detritus. Later reference will be made to the difference between soils carried down in recent geological times by the big River and its tributaries and soils

probably deposited by rivers like the Dihing from the Tertiary rocks of the Patkoi.

It is generally assumed that the Patkoi and the Himalayas, in their later growth at least, are of contemporaneous development and are both distinct from the mountain systems of Upper Burma, Tibet and western China. The termination of either range is the head of the Assam Valley.

The development of the tea industry in Lakhimpur.

The early history of tea in the Lakhimpur district is bound up with the history of the British connection with the province of Assam (4).

Many Europeans, who had had experience in Upper Assam during the early part of the nineteenth century, knew that tea was growing in the country of the hill tribes (Singphos), at the north-eastern end of the valley, and was used for making tea by the Burmese method, *i.e.*, lepet or pickled tea. This fact was mentioned in 1815 by Colonel Latter and in 1818 by Mr. Gardner.

In 1823 Mr. R. Bruce, an adventurer and trader, visited Garhgaon, near Sibsagar, for trading purposes and, having heard of the existence of tea plants in the neighbouring district from a Singpho chief, made arrangements to obtain some specimens. In the following year these arrived and were made over to his brother, Mr. C. A. Bruce, who was on service, in charge of a flotilla of gunboats at Sadiya, in the Burmese war then in progress. In 1825, at the end of the war, C. A. Bruce settled in Sadiya and put out most of the tea plants in his garden. A few specimens were sent to Capt. David Scott, the first Commissioner of the newly acquired province of Assam, and he forwarded some of them to Calcutta for identification, together with supposed tea leaves he himself had discovered in Manipur.

(4) Watt, Sir Geo., Tea and the Tea Plant, *Jour. Roy. Hort. Soc.*, London, 1906 (vol. 32).

Mann, H. H., The Early History of the Tea Industry in North East India, *Bengal Economic Jour.*, Calcutta, 1918.

Cohen Stuart, C. S., A Basis for Tea Selection, *Bull. Jardin Botanique*, Buitenzorg, 1919 (vol. 1, fasc. 4).

Gait, Sir Ed., A History of Assam, 2nd ed., Calcutta, 1926 (pp. 352).

Identification was, of course, impossible without seed or flower, but the leaves were pronounced to be of the same family, but not the same species as the plant from which the Chinese manufacture tea. Little attention was paid to the matter at the time and the Bruce-Scott plant does not appear to have been preserved in any herbarium.

In 1833, the East India Company, having lost its monopoly of the tea trade with China, was anxious to obtain a rival source of supply under its own control. With this object, Lord Bentinck, the Governor-General of India, appointed a committee in 1834 to consider the question of tea growing in India. This committee issued a circular inviting all opinions which might be of any value as to where tea in India was likely to be successful. At the same time, the Secretary of the committee, Mr. G. J. Gordon, of the Calcutta firm of Mackintosh & Co., was sent to China to bring back plants and seed and also cultivators who knew how to grow and prepare tea.

The opinions obtained from the circular, based on analogies, often false ones, of climate and soil, convinced the tea committee that the proper places for tea cultivation in India were, in order of suitability, (*a*) the lower hills and valleys of the Himalayas (indicating Mussoorie, Dehra Dun, *etc.*), (*b*) the eastern frontier and (*c*) the Nilgiries and mountains of central and south India. Exactly which area was denoted by the eastern frontier was not stated.

The circular had been received by Capt. Jenkins, then in charge of the Assam Valley, stationed at Gauhati, who passed it on to Lieut. Charlton, on service at Sadiya. As a result of this, complete tea plants, including seed and flowers, together with made tea, all obtained near Sadiya, were despatched to Calcutta (on 8th November, 1834) and were identified with certainty as the same species as the China tea plant.

This re-discovery of tea in Assam caused a stir in interested circles in Calcutta. Dr. N. Wallich, then Superintendent of the Botanical Gardens, considered that, in view of the presence of

tea in India, the importation of China stock was a waste of time. Partly on this account, Gordon was recalled from China, although not before he had despatched several lots of seed to India.

In the meantime local progress had been considerable. Tea was discovered in the Manipur Hills, in Tippera, and in new localities in the Assam Valley. Later, Lieut. Charlton was called out to subdue a rebellion, in which he was wounded, and had to leave the province. Bruce then took over the experiments and became the principal figure in the local development of tea culture for a good many years.

In 1835, a scientific deputation was sent to Assam to report on the possibilities of developing the tea industry there. The deputation consisted of Dr. N. Wallich, Dr. W. Griffith, a noted botanist, and J. McClelland, a geologist. The party reached Sadiya in 1836 and found the tea nurseries there, grown from seed sent from China, in a bad way, over-grown with weeds, suffering from cattle trespass and the poor soil. Of the 20,000 plants sent up from Calcutta, only 500 were alive.

The deputation found tea in many parts of the valley, including Kutchu, Negrigram, Nadua, Tingri, Gabru-Purbat and Borhat, besides in the hills between Assam and Burma. No plants were found north of the Brahmaputra River and those found on the plains were always in groups, almost as if they had been planted. The Matak country, between the Dibru and Dihing rivers, was full of such groups. As the country had been desolated by war for many years it is quite probable that the tea bushes found on the plains had been planted. Only in the Singpho Hills did they become apparently part of the ordinary vegetation. Thus the question whether tea is indigenous to Assam was left doubtful and so it has remained.

On other points, Wallich and Griffith had differences of opinion. The former considered the Himalayan region better for tea than Assam, but did not agree to the importation of China

seed. Griffiths favoured Assam, but considered that the local plant was a cultural variety of the China plant, and hence advocated the importation of plants and seeds. Griffiths had his way and, accordingly, Gordon was sent back to China for seed and plants.

In 1836, C. A. Bruce was made Superintendent of the Government Tea Forests and during the next few years did very fine pioneer work. In 1838 he published a pamphlet (5), which included a map showing the extent of his discoveries of wild tea. In the Matak country he located 80 tea tracts, in the Singphos 12 and west of the Buri Dihing 28. The last were notably at Namsang, Tipam, Jaipur and in the neighbourhood of Rungpore (Sibsagar) and Gabru.

When the first seeds sent by Gordon arrived from China, they were sown in Calcutta early in 1835, and the young plants, 42,000 in number, were distributed between Assam, the Himalayas and the Nilgiries. The plants did well in the Himalayas, practically all those sent to the Nilgiries died, whilst those sent to Assam were planted on a sandy *chur* at Kundilmukh, where, as previously mentioned, most of them failed.

Besides these ill-fated plants, a beginning was made with the exploitation of wild Assam tea, and in one case, in order to "work up or reclaim the Assam plant as rapidly as possible" (Griffith), wild and China tea were interplanted. The result ended, happily, in the death of both varieties. Meanwhile many jungle patches of tea were cleared with varying success.

In 1838 a new plantation of China tea was put out at Jaipur and, later, one at Deenjoy, Chabua. A few of the original plants are said still to exist at Jaipur, planted 6 ft. by 6 ft. At Chabua, the supposed original tea, now abandoned, can be seen, planted

(5) An Account of the manufacture of black tea as now practised at Sadiya in Upper Assam, by the Chinaman sent thither for the purpose, with some observations on the culture of the plant in China and its growth in Assam.

in irregular lines. In 1838 or 1839 three more gardens were put out, one near Deohall, the second in Chota Tingri, and the third at Hukanpukri.

The first manufactured tea, good enough to send to Calcutta, was produced in 1836, although during this year and the next only small samples were produced. In 1838 enough was produced for despatch to England where it was awaited with great interest. At its sale in January, 1838 it sold for an average of more than 20 *s.* per pound, a price indicative not of its true value but of its novelty. All this tea was manufactured after the Chinese manner by imported Chinamen. The present method of black tea manufacture which differs in many ways from that employed in China, was evolved in Assam and has since been adopted in other countries where the tea industry is under European control.

It having now been proved that tea could be made in Assam, a number of capitalists approached Government, both in London and Calcutta, for the transfer of the Government plantations to themselves. A company termed the Bengal Tea Company was formed in Calcutta in 1849 and in the same year a joint stock company was also formed in London with a similar object, *viz.*, the purchase of the East India Company's plantations and establishment in Assam for the purpose of carrying on tea cultivation there. The two companies almost immediately amalgamated as the Assam Company. In 1840, two-thirds of the experimental tea areas was handed over to the new company, and C. A. Bruce was appointed Superintendent of the Northern Division, with head-quarters at Jaipur.

Chabua had been sold by Government to a Chinaman in 1840, but in 1851 it was taken over by Messrs. Warren and Jenkins who in the next year entered on the formation of the Maeejan Tea Barree. In the same year, Colonel Hannay, and officer whose efforts contributed much to the development of the industry, extended his tea area in his garden close to Dibrugarh.

In 1859 the tabular statement of tea established in Assam, issued by Col. Jenkins, the Agent Governor-General of Assam, included the following gardens in Lakhimpur.

Names of Proprietors.	Factories.	Total acreage.	Acres under tea.
Assam Company	Tingrai	1,525	400
Warren & Jenkins ...	Chabua & Dikkom	252	170
Col. Hannay	Dibroo, Mottolah and Bazaloni ...	4,357	220
R. Barry	Maijan	1,890	170
Higgs, Melang and Sevenoaks	Maunkatto	1,540	150
Col. Reid	Sook Doongia ...	899	130
H. Melang	Bakparah	294	70
G. R. Barry	Bor Barooah ...	1,058	160
Barry & Wagentrieber ...	Nagaghooli	937	150
A. C. Campbell & Co. ...	Deohall	1,286	80

The total tea produced in 1859 was 282,000 lbs.

From 1859 to 1863 was a period of steady expansion followed by a depression which continued till 1869. Statistics for the early years during which the industry was developing are not readily available and are too inaccurate to deserve attention. In 1874 it is said that in Lakhimpur there were 11,680 acres in bearing, in 1832, 32,952 acres. In 1900 the area had risen to 67,500 acres with an outturn of 25,698,000 lbs.

In 1927 there were 214 gardens comprising 100,734 acres under tea, producing 67,772,919 lbs. The actual area of tea plucked in that year was 93,387, giving an average crop of about 725 lbs. tea per acre. Lakhimpur is the highest yielding tea area in North-East India.

Although much of the Dibrugarh district was originally planted out with China tea, this has been steadily uprooted and replaced by the Assam jat, so that to-day only a very small area of China remains.

The tea areas have naturally spread from the more to the less accessible spots, from the rivers inland and, generally speak-

ing, the gardens in the east of the district are younger than those in the west and south. The newest area which is now in process of opening out is to the east of Doom Dooma, in the Lakhimpur Frontier Tract and almost in Khamti country. This area is spoken of as the Burhi Dihing district.

The Lakhimpur division is divided in five circles of the Indian Tea Association, *viz.*, North Lakhimpur, Dibrugarh, Panitola, Doom Dooma and Tingri. The North Lakhimpur circle, comprising about 7,800 acres of tea, has already been dealt with (this Journal, pt. IV, 1923). The other circles are in the Dibrugarh sub-division.

As denoted by the crop returns, the tea in Dibrugarh is very fine and, in addition, the average prices obtained are second only to those of Darjeeling in North-East India. This high quality is largely the result of fine, regular plucking and care taken in every branch of manufacture, for the factories are well found and the finest in North-East India. Sufficient withering space is provided to allow of the keeping of leaf over 24 hours if necessary till some sort of wither is obtained, and enough machinery is installed to cope with the biggest cropping days.

The accompanying sketch map shows the relative positions of the tea gardens. The official spelling of garden names, which is not always the same as that employed by the tea company, has been adopted.

Climate.

The climate of Lakhimpur is highly favourable to tea. The position at the head of a funnel shaped valley, so placed to receive the most winds from the Bay of Bengal, is particularly inducive to rainfall, and clouds are wafted by a south-west breeze to the top of the valley where precipitation eventually occurs.

The Lakhimpur rainfall is the most reliable in the province of Assam. The table below shows the average monthly precipitation at Dibrugarh, Doom Dooma and North Lakhimpur

together with that at Tocklai, Silchar and Sylee, the last three representing Middle Assam, the Surma Valley and the Duars respectively.

	Dibrugarh.	Doom Dooma.	North Lakhimpur.	Tocklai.	Silchar.	Sylee.
	ins.	ins.	ins.	ins.	ins.	ins.
January ...	1·53	1·47	1·71	1·00	0·75	0·47
February ...	2·55	2·79	2·26	1·56	2·18	0·74
March	4·99	5·93	4·27	3·62	7·53	1·12
April	9·94	10·69	10·02	8·09	13·96	3·99
May	13·14	10·63	16·64	9·16	15·19	11·09
June	18·93	15·80	22·34	12·90	20·75	33·43
July ...	21·24	19·58	22·53	16·72	20·33	44·56
August ...	18·70	16·27	21·21	13·30	19·00	28·21
September ...	13·80	10·58	16·76	10·79	14·39	28·07
October... ...	5·53	4·49	6·59	4·61	6·55	7·49
November ...	0·91	0·64	1·11	0·90	1.43	0·98
December ...	0·60	0·43	0·56	0·33	0·45	0·19
TOTAL ...	111·86	99·30	126·00	82·51	122·53	164·48

The average rainfall for the Lakhimpur district south of the Brahmaputra, is about 100 inches. Thus at Margherita it is 101.56 ins., at Jaipur 99.99 ins., at Wilton 104.44 ins. and at Moran 92.04 ins. At Sadiya the value is 107.10 ins., but at Pasighat, nearer the hills, the value rises to 180,54 ins. Correspondingly high values are obtained in North Lakhimpur where at Pathalipam the annual precipitation is 168.46 inches.

Temperature records are not available in such great number as those of rainfall. The average values for the Assam Valley tea districts do not vary widely although notable differences

occur between Assam and the Surma Valley and the Duars, as the effects of drought.

	Dibrugarh.		Silchar.		Dam Dim (Duars).	
	max.	min.	max.	min.	max.	min.
	°F.	°F.	°F.	°F.	°F.	°F.
January	71	49	78	52	80	44
February	72	54	81	56	81	46
March	78	60	86	63	86	53
April	80	65	88	69	89	64
May	84	71	89	73	91	70
June	87	74	89	76	91	74
July	87	75	90	77	91	75
August	87	76	90	77	91	75
September	87	75	90	76	92	74
October	85	70	88	72	91	66
November	79	60	85	64	87	54
December	73	50	80	55	85	43

The most notable advantage shown by Dibrugarh is the low maximum temperatures in the dry season. These, combined with the frequency of the cold wealther mists, do much to mitigate the effect of drought.

Lakhimpur soil types.

In the present soil survey it is proposed to deal with the tea estates situated in the Dibrugarh sub-district, with the exception of a few gardens which are in the Moran and Sonari Circles. These gardens will be treated in the soil survey of the Sibsagar sub-district.

The general classification of soils is admittedly a difficult task. Thus a classification based on geological origin will not serve in regions where the climate differs widely, for the same rock may give rise to totally different soils according to climate and the degree to which the disintegrating process has proceeded. Classification on a purely physical basis is scarcely more satisfactory, since, as such, it may involve the grouping together of soils otherwise absolutely unrelated. Such a classification is, however, of practical importance and is the one adopted in the

present article. The broadest classification is related to the mode of operation of rock disintegration and rests ultimately on a climatological basis. The original materials may differ, but the constant working of a given set of conditions tends to produce the same product.

On this climatic basis, the tea soils of Lakhimpur and of Assam are classed as lateritic. The general tendency is for the water movement to be downward through the soil, resulting in the removal of soluble constituents and the accumulation of iron and aluminium on the soil. The alluvium of Lakhimpur is, geologically speaking, young and, except on the older red banks near the hills, laterisation has not proceeded far. Broadly speaking, it may be said that in Assam the older the soil the redder and more acid it is.

During the last re-settlement of the Lakhimpur district the land was divided into the following classes, according to the crop it was capable of carrying.

1. *Bari;* homestead, bearing fruit trees, etc.
2. *Daw-rupit;* transplanted rice land of low level.
3. *Bam-rupit;* land fit for transplanted rice but of higher level than daw-rupit.
4. *Taklabari;* poor homestead land.
5. *Foringati;* high land unsuited to transplanted rice.
6. *Jalutak;* land subject to flooding and capable of bearing a precarious rice crop.
7. Tea land; all land taken up for tea cultivation.

The best tea land is high land, preferably that which has been under jungle. Low land, *i.e.*, rice land, can be planted out with tea but not always successfully. Grazing land often grows poor tea until it has been cultivated for some years.

The Lakhimpur tea soils are below classified according to their physical constitution. The mechanical analyses quoted have been carried out by Hall's method which divides the smaller soil particles into 5 groups, *viz.*, coarse and fine sand, silt and fine silt and clay. Taking the whole area broadly, the predominant fraction is fine sand followed by silt, coarse sand, fine silt and clay. Stones do not occur in the tea areas of the Dibrugarh sub-district, and gravel is rare. The following type may be taken as the average soil for the district.

Fraction.		*Fraction number.*
Coarse sand	19%	1
Fine sand	30%	2
Silt	20%	3
Fine silt	13%	4
Clay	12%	5

Soil type 2, 3, 1, 4, 5.

Each fraction is denoted by a number by which it is called. Thus No. 1 indicates coarse sand, No. 2 fine sand and so on. The type nomenclature adopted by this Department is illustrated above, the type-chain being arranged in the descending order of the magnitude of the fractions.

In England such a soil as the above is termed a light loam and would be described as free working, warm and early. Such soils stand drought well, are grateful and fairly retentive of manure and usually have subsoils of a like texture. This last characteristic is borne out by the available analyses of the Lakhimpur soils. As soon as the finer soil particles predominate there is a tendency for the subsoil to be stiffer than the top.

Taking the soils from one end of the district to the other there is only a small variation in texture. The Dibrugarh and Nadua soils are, on the whole, similar and a little stiffer than those in Panitola. The Doom Dooma soils are more friable than those of Panitola, containing more coarse sand and somewhat less silt.

The Tingri soils resemble those of Panitola. The table below gives a very general idea of what order of variation exists between the districts.

	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Type.
	%	%	%	%	%	
Dibrugarh ...	13	29	23	16	14	2, 3, 4, 1, 5
Nadua ...	14	32	20	16	13	2, 3, 4, 1, 5
Panitola ...	19	31	17	17	11	2, 1, 3, 4, 5
Doom Dooma ...	24	29	18	13	11	2, 1, 3, 4, 5
Tingri ...	19	32	21	9	12	2, 3, 1, 5, 4

The table shows the predominance of the fine sand fraction in all areas, the increase in coarse sand from Dibrugarh to Doom Dooma and the slight decrease in clay along the same line.

In Dibrugarh many of the soils contain much less coarse sand than 13%, shown by the average in the table, and greater proportions of fine sand and silt than are shown in the table above. Such soils are liable to run and dry with a caked surface if much rain falls after cultivation. The reason for this is that the finer fractions, *viz.*, 2-3-4, have neither the weight of coarse sand nor the structure of clay aggregates to withstand washing.

Chemically, the Lakhimpur soils are not remarkable for their richness, and the goodness of the tea in this area must be attributed, so far as the soil is concerned, to its good texture and depth, rather than to any particular chemical property. The loss on ignition, which is some measure of the organic matter, varies from 4 to 6% with 4.5% as an average. The Grandeau organic matter or available organic matter is about 1.5%. The total nitrogen is about 0.100%, the available potash about 0.014% and available phosphoric acid about 0.012%. None of these values are very good and are exceeded by many soils in other tea districts of North-East India.

The insoluble siliceous matter is about 82% as against about 90% in the Jorhat district and 65% on the Red Bank of the

Dooars. The insoluble siliceous matter varies largely as the clay fraction in the soil and is some indication of the potential plant food in the soil. Some soils are, however, inherently less soluble than others. The Jorhat soils contain much insoluble silica and, partly on this account, are poorer than the Dibrugarh soils. One probable explanation of the big difference in the insoluble siliceous matter of the alluvial soils of the valley is difference of origin. Thus it seems likely that the soil of parts of the Bishnath and Jorhat districts were laid down directly from the Brahmaputra in recent geological times. On the other hand the soils of the Dibrugarh sub-district appear to have been washed down at an earlier period from the land mass of the Patkoi.

The table below gives a general idea of the constitution of the Dibrugarh soils.

	Dibrugarh.	Panitola.	Doom Dooma.	S. Tingri.
	%	%	%	%
Mechanical Analysis.				
Coarse sand ...	13	26	29	31
Fine ,, ...	35	27	30	28
Silt ...	26	22	16	16
Fine silt ...	4	6	7	10
Clay ...	17	13	12	10
Loss on ignition ...	4·16	5·44	5·16	4·62
Chemical Analysis.				
Grandeau organic matter	1·51	1·37	1·86	1·64
Nitrogen ...	0·090	0·131	0·109	0·113
Available phosphoric acid	0·006	0 011	0·017	0·007
,, potash ...	0·008	0·017	0·016	0·007
,, lime ...	0·025	0·061	0·057	0·057
Acidity (Hopkins) ...	560	190	130	533
Insoluble silicious matter	82	83	84	87

The south Tingri sample is taken from Achabam, south of the Dihing, and is somewhat different from the normal run of Tingri soils.

The acidity of the soil is regarded as one of the chief factors in deciding the suitability or otherwise of an area for tea in North-East India. The Hopkins value quoted in the table above is largely a function of the clay and with a run of similar soils varies with this soil fraction. The pH value or strength of the soil acid is however independent of the quantity of clay and should be about 5.4 on a good tea soil. In most cases of failure to grow tea in North-East India it can be shown that, provided no cultural factor is involved, the acidity of the soil is too low. The acidity varies to some extent with the available lime content which should be about 0.05%. Good tea, however, may grow on soils showing pH and lime values very wide on either side of the figures mentioned, if other factors are favourable.

Before fresh areas are put out under tea it is suggested that soil samples be sent to Tocklai for acidity estimations.

The manurial treatment of Lakhimpur soils.

In considering the manurial treatment of Lakhimpur soils, or in fact of any tea soil in North-East India, it may be assumed that nitrogen and organic matter should be the main features of any scheme. The Lakhimpur soils contain enough clay to hold soluble inorganic manures and full advantage of this cheap means of supplying plant food may be taken. Under most circumstances a five-year manurial cycle is suggested because this requires a convenient part of the garden, about two-fifths, to be green cropped each year. The following is a suitable manurial treatment.

A—Sulphate of ammonia 1½ cwt.
Sulphate of potash ½ cwt. } in March or April.

B—Mineral phosphate or basic slag 2 cwt. and any suitable eight-week green crop.

When the crop is buried broadcast 1½ cwt. nitrate of soda.

C—Mixture as in A.

D—Sulphate of ammonia 1½ cwt.
Muriate of potash ½ ,,
Superphosphate 1 ,,
} in March or April.
Sow Rahar or Boga medeloa in alternate lines. Lop and thin regularly. Bury Rahar at end of season.

E—Mixture as in D.
Bury Boga medeloa.

This cycle needs modifying to meet special conditions. In the five years the nitrogen/potash/phosphoric acid given per acre in the form of artificials equal about 157/112/104 lbs. respectively per acre.

It will be observed that the cycle requires that 20% of the garden shall be under a quick growing green crop and 20% planted with a semi-permanent green crop each year. The acreage under a quick growing green crop may be reduced by applying cattle manure at the rate of 5 tons per acre under B.

In putting 1/5 of the garden under a ground green crop yearly it is assumed that the tea is small enough to allow of the successful growth of such a crop. In fitting a manure cycle to a garden in which all the tea is well grown and touching, the first consideration must be to arrange that any blocks which during the ensuing five years are to be cut back, shall receive their ground green crop in that year. Part of the rest of the area under treatment B may receive cattle manure and, if there still remains an area on which a ground green crop cannot be grown, this should receive a complete mixture similar to that suggested under treatment D. It is some consolation to know that areas of fully grown tea in which the bushes meet, are in less need of green cropping than areas of small tea in which the sun directly beats down on the soil. This particularly holds if the tea is, in addition, well shaded, for shade trees supply appreciable quantities of organic matter to the soil.

The growth and burial of a green crop produces a depressant effect on the tea. To minimise this the application of nitrate of soda is suggested at the time when the green stuff is turned in. The growth of Boga medeloa in clumps is possible in practically any tea if it is sown early enough.

The Calcutta cost of the above cycle, not counting freight, application and cost of seed, is about Rs. 20/- per acre per annum.

In most cases the soils of Lakhimpur are of normal acidity and in some cases under acid. They are hence able to stand repeated doses of sulphate of ammonia. In cases where soils are extremely acid the substitution of calcium cyanamide for sulphate of ammonia is suggested in one or two years. This necessitates certain small alterations in the cycle. Calcium cyanamide is an alkaline manure leaving a lime residue in the soil which, in addition to its property as a corrector of acidity, assists the growth of green crops in year B. Accordingly, this manure should be applied in the year A.

In suggesting a manurial cycle it is often a great help to this Department to receive one or two typical soil samples for acidity estimations. The estimations of pH values are not at present made by the Calcutta analysts but are carried out at Tocklai.

THE MECHANICAL ANALYSES OF LAKHIMPUR SOILS.

Comparatively few soil analyses of the Lakhimpur district are available, many of those being of an early date. Although soils do not change appreciably within a few years, analytical methods have been modified in the past decade and it is suggested that analyses made much prior to 1920 should now be repeated on fresh samples.

In the tables below representative analyses from each garden are shown and not more than two analyses of similar soils from the same garden are quoted. The soils of each garden are placed in the ascending order of the coarse sand percentage so that, in most cases, the heavier soils come first.

Dibrugarh.

The first table shows analyses from gardens situated along the road from Dibrugarh to Khowang.

Sample.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ignition.	Soil type.
Chowkidinghi ...	11	32	22	16	12	4·49	2, 3, 4, 5, 1
Borbarooah No. 22 ...	9	47	12	13	12	4·49	2, 4, 3, 5, 1
,, ...	23	26	22	9	15	5·80	2, 1, 3, 5, 4
Lepetkatta No. 2 ...	14	7	42	22	10	4·42	3, 4, 1, 5, 2
,, ,, 15 ...	14	10	42	12	15	5·95	3, 5, 1, 4, 2
Medla No. 3 ...	11	16	37	17	14	3·84	3, 4, 2, 5, 1
,, ,, 1 ...	13	7	47	16	11	5·95	3, 4, 1, 5, 2
Boro Dewan ...	12	37	16	23	8	3·98	2, 4, 3, 1, 5
Chota Dewan ...	21	34	8	20	12	3·73	2, 4, 1, 5, 3
Boyle No. 14 ...	6	14	28	26	20	3·99	3, 4, 5, 2, 1
,, ,, 9 ...	20	8	45	14	10	2·72	3, 1, 4, 5, 2

The soils showing silt and fine silt as major fractions, *i.e.*, types 3 and 4, are inclined to be stiff and to pack hard in the cold weather, unless they are liberally treated with organic matter.

The second table shows Borbarrie, Ethelwold and Mothola samples.

Sample.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ignition.	Soil type.
Borbarrie 10A, 8A, 2B	2	17	31	27	15	7·11	3, 4, 2, 5, 1
,, 13A high ...	3	26	21	30	12	7·02	4, 2, 3, 5, 1
,, 1A ...	3	31	27	19	12	5·49	2, 3, 4, 5, 1
,, 13A low ...	4	9	17	36	24	8·13	4, 5, 3, 2, 1
,, 15A ...	6	24	21	24	20	6·39	2, 4, 3, 5, 1
Ethelwold No. 17 ...	5	44	12	17	14	6·40	2, 4, 5, 3, 1
,, ,, 22 ...	13	24	14	24	18	6·35	4, 2, 5, 3, 1
,, ,, 5 ...	14	24	20	24	12	4·57	2, 4, 3, 1, 5
Mothola Nos. 4 & 2 ...	13	32	21	16	8	5·02	2, 3, 4, 1, 5
,, No. 5 ...	15	38	24	15	8	3·18	2, 3, 1, 4, 5
,, Dullonee ...	52	30	5	5	6	3·80	1, 2, 5, 4, 3

The Borbarrie samples are all stiffish soils, lacking in coarse sand but rich in organic matter. The samples from No. 13A

Borbarrie would suggest that soil had been washed from the high to the low section, during which process mainly clay was moved. The Ethelwold samples are medium loams, generally intermediate in heaviness between Borbarrie and Mothola. The Mothola samples Nos. 5 and 2 are light loams. Dullonee is a very light sand, probably laid down from a swift running river which dropped the heavy particles and carried on the finer ones.

The next table includes analyses from Maijan and Nagaghoolie.

Sample.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ignition.	Soil type.
Maijan ...	11	38	20	16	10	4·83	2, 3, 4, 1, 5
,, ...	28	26	11	16	12	5·83	1, 2, 4, 5, 3
,, No. 10 ...	30	27	21	4	12	4·97	1, 2, 3, 5, 4
,, ,, 14 ...	30	36	8	13	6	4·90	2, 1, 4, 3, 5
Nagaghoolie No. 4 ...	11	39	19	19	5	5·79	2, 3, 4, 1, 5
,, ,, 9 ...	19	20	19	24	15	7·04	4, 2, 3, 1, 5
,, ,, 20 ...	33	14	19	8	18	7·87	1, 3, 5, 2, 4

Representative analyses are taken from these two gardens. At Maijan several types are seen. The first is a close knit soil liable to give trouble unless it is well green cropped, the others are loams of various degrees of lightness. Nagaghoolie No. 4 is a silt similar to the first sample at Maijan. No. 20 is a very fine loam containing useful quantities of coarse sand and clay. No. 9 is a medium clay.

Sample.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ignition.	Soil type.
Rajabhetta No. 13-15	20	26	31	7	11	4·79	3, 2, 1, 5, 4
,, ,, 14 ..	34	12	25	5	9	6·59	1, 3, 2, 5, 4
Basmatia No. 8 ...	5	40	30	5	16	4 47	2, 3, 5, 1, 4
,, ,, 4 ...	13	35	26	4	17	4·16	2, 3, 5, 1, 4

At Rajabhetta the types vary little. The Basmatia soils are fine sandy loams, No. 8 being of a type liable to pack hard in the cold weather.

The next table includes typical analyses from several gardens situated in the eastern part of the Dibrugarh district.

Sample.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ignition.	Soil type.
Rajghur No. 7 ...	7	45	22	7	13	4·38	2, 3, 5, 4, 1
Mohunbari No. 7 ...	5	42	19	17	12	5·26	2, 3, 4, 5, 1
,, ,, B ...	19	24	32	4	14	6·38	3, 2, 1, 5, 4
Greenwood, west ...	6	30	27	19	13	6·19	2, 3, 4, 5, 1
,, east ...	28	14	19	22	10	5·89	1, 4, 3, 2, 5
Titadimaru No. 2 ...	7	31	16	21	19	5·39	2, 4, 5, 3, 1
,, ,, 4 ...	16	34	12	51	17	5·92	2, 5, 1, 4, 3
Hazelbank 25-20 ...	5	31	20	25	12	6·67	2, 4, 3, 5, 1
Thanai No. 12 ...	11	16	17	29	20	7·55	4, 5, 3, 2, 1
,, ,, 4 ...	14	37	16	19	10	6·14	2, 4, 3, 5, 1
,, ,, 1 ...	21	43	13	11	9	3·46	2, 1, 3, 4, 5
Bellaguri ...	14	16	18	29	16	6·97	4, 3, 5, 2, 1

Of Rajghur only one analysis is available showing a medium loam. At Mohunbari, Greenwood and Titadimaru two types, a light and a somewhat heavier loam, are met. In most cases the light loam approximates to the Doom Dooma type. At Hazelbank all the analyses show the same type of medium loam. At Thanai, loams of various degrees of lightness occur.

Sample.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ignition.	Soil type.
Singlijan No. 1 ...	13	36	22	12	11	4·76	2, 3, 1, 4, 5
,, ,, 3 ...	17	27	22	9	17	6·46	2, 3, 1, 5, 4
Romai No. 14 ...	14	38	14	16	12	5·93	2, 4, 3, 1, 5
,, ,, 2 ...	32	38	9	10	8	6·46	2, 3, 1, 5, 4

Of the Singlijan samples No. 3 is the stiffer but the better soil as shown by the greater loss on ignition. At Romai, both types common in the district occur.

At Sealkotee and Chabua, the analyses on which are shown in the next table, many types are met, although the main type is the fine sandy loam common to the district.

Sample.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ignition.	Soil type.
Sealkotee No. 33 ...	4	30	25	21	15	5·06	2, 3, 4, 5, 1
,, Ridgway No. 6	6	33	30	12	14	4·90	2, 3, 5, 4, 1
,, No. 7 ...	9	20	38	10	17	5·57	3, 2, 5, 4, 1
,, ,, 20 ...	17	30	27	7	13	4·04	2, 3, 1, 5, 4
,, ,, 36 ...	22	29	11	17	14	5·52	2, 1, 4, 3, 5
Chabua No. 5 Til. ...	1	28	29	13	21	6·03	3, 2, 5, 4, 1
,, ,, 39 Hil. ...	6	48	16	16	10	4 90	2, 4, 3, 5, 1
,, ,, 37 Sham. ...	13	36	18	16	12	4·66	2, 3, 4, 1, 5
,, ,, 4 Pom. ...	15	24	21	11	21	6·52	2, 5, 3, 1, 4
,, ,, 6 Huk. ...	23	21	17	11	21	5·60	1, 5, 2, 3, 4

The last three samples of both gardens represent loams the friability of which increases from the first to the third sample. Some of the other soils are fairly stiff clays requiring careful handling.

Panitola.

In this district as in Dibrugarh the soils are loams of various degrees of lightness. The fine sand, as throughout the whole of Lakhimpur, is the predominant fraction but coarse sand is a bigger fraction than in Dibrugarh, and the soils are, accordingly, lighter on the whole.

Sample.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ignition.	Soil type.
Balijan No. 26 ..	4	42	21	18	10	5·02	2, 3, 4, 5, 1
,, ,, 36 A ...	9	44	26	5	11	5·17	2, 3, 5, 1, 4
,, ...	15	16	14	30	19	6·69	4, 5, 2, 1, 3
,, No. 34 ...	36	19	18	11	10	8·30	1, 2, 3, 4, 5
Kharjan No. 3 ...	11	32	18	21	11	6 02	2, 4, 3, 1, 5
,, ,, 1 ...	13	12	16	33	18	6·33	4, 5, 3, 1, 2
,, ...	43	34	7	8	5	3·87	1, 2, 4, 3, 5
Kanjikoah No 7 ...	4	41	22	17	13	4·08	2, 3, 4, 5, 1
,, ,, 2 ...	10	31	14	21	16	3·68	2, 4, 5, 3, 1
,, ...	23	28	15	17	9	6·40	2, 1, 4, 3. 5
Panitola No. 4 D ...	8	42	17	17	10	5·50	2, 4, 3, 5, 1
,, 106 F. S. ...	19	21	19	24	12	5·31	3, 2, 3, 1, 5
,, 26 N. P. ...	30	31	11	16	6	5·25	2, 1, 4, 3, 5

At Balijan the best soil is No. 34 which is of good texture and shows a high loss on ignition. Kharjan, Kanjikoah and Panitola exhibit normal types, except in the case of the third sample at Kharjan, which is an exceptionally light sand similar in texture to that on Dinjan No. 20 in the next table.

Sample.	Coarse sand	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ignition.	Soil type.
Dinjan No. 30 ...	22	27	12	19	11	6·23	2, 1, 4, 3, 5
,, ,, 8 ...	26	14	12	26	12	8·20	4, 1, 2, 5, 3
,, ,, 10 ...	28	34	12	13	15	5·65	2, 1, 4, 3, 5
,, ,, 32 ...	31	23	17	15	7	5·89	1, 2, 3, 4, 5
,, ,, 20 ...	43	31	5	9	5	5·33	1, 2, 4, 3, 5
Kamptigwalli ...	18	34	16	16	11	4·49	2, 1, 3, 4, 5
Woodbine No. 2 ...	23	25	13	17	4	5·15	2, 1, 4, 5, 3
Rangagora ...	18	30	14	17	13	5·18	2, 1, 4, 3, 5
Nakhroy ...	8	18	27	28	12	6·22	4, 3, 2, 5, 1
,, No. 10 ...	12	42	13	19	9	6·00	2, 4, 3, 1, 5

At Dinjan many types are met, all with coarse sand as a major fraction and in two instances as the biggest fraction. Kamptigwalli shows a good loam and Woodbine rather a light sand somewhat deficient in clay. The Rangagora and first Nakhroy samples are common ones, but the 2-4 type occurring on Nakhroy No. 10 is rare in the district.

The last table of soils from the Panitola district shows Limbuguri and Dhelakhat samples. Some of the latter, especially those on village sites, are extremely rich in phosphoric acid, a common characteristic of soils from such locations.

Sample.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ignition.	Soil type.
Limbuguri	10	36	14	17	15	5·82	2, 4, 5, 3, 1
,, ...	15	36	13	19	12	6·18	2, 4, 1, 3, 5
,, ...	26	31	12	13	12	5·31	2, 1, 4, 3, 5
Dhelakhat No. 11 ...	6	40	24	10	14	5·23	2, 3, 5, 4, 1
,, ,, 12 ...	23	27	18	10	16	5·60	2, 1, 3, 5, 4
,, ,, 13 ...	32	26	19	7	11	4·88	1, 2, 3, 5, 4
,, ,, 7 ...	39	22	12	11	10	4·90	1, 2, 3, 4, 5

The lighter soils in Panitola, resembling the Doom Dooma sandy loams, become commoner from west to east.

Doom Dooma.

The first Doom Dooma table takes in gardens near Tinsukia and Makum. They are practically all of the 2-3 type, *i.e.*, with fine sand and silt as major fractions, with the coarse sand fraction relegated to the end of the type chain. These soils are much heavier than the light sandy loams common on what is termed the Doom Dooma Bank, but they resemble many of the soils in the Tingri district.

Sample.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ignition.	Soil type.
Kachujan No. 13 ...	4	44	16	18	12	6 06	2, 4, 3, 5, 1
Hukanpukri No. 6 ...	4	50	17	17	7	4·38	2, 3, 4, 5, 1
Betjan No. 13 ...	8	36	20	15	13	5·24	2, 3, 4, 5, 1
Hapjan No. 8 ...	1	22	31	19	11	5·09	2, 3, 4, 5, 1
„ „ 2 ...	2	50	21	17	4	3·43	2, 3, 4, 5, 1

The next table shows typical soils from Longsoal, Hukonguri and Hilika. Most of the soils are sandy loams.

Sample.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Less on ignition.	Soil type.
Longsoal No. 8 ...	10	40	21	10	14	4·40	2, 3, 5, 4, 1
„ „ 22 ...	12	28	18	21	12	7·00	2, 4, 3, 5, 1
„ „ 20 ...	25	31	11	15	8	7·48	2, 1. 4, 3, 5
„ „ 4 ...	29	30	16	7	12	5.16	2, 1, 3, 5, 4
„ „ 13 ...	35	16	16	16	8	6·25	1, 2, 4, 3, 5
Hukonguri No. 12 ...	10	34	22	15	14	4·45	2, 3, 4, 5, 1
„ ...	11	45	14	15	11	3·76	2, 4, 3, 1, 5
„ ...	28	35	8	16	8	4·23	2, 1, 4, 3, 5
Hilika	14	18	28	15	18	5·33	3, 5, 2, 4, 1
„ No. 9 ...	22	31	26	9	3	5·29	2, 3, 1, 4, 5
„ „ 15 ...	41	22	12	13	10	5·91	1, 2, 4, 3, 5

In several cases above, the coarse sand becomes a major fraction and it is never less than 10% of the soil. There appears to be a decided change between the former group of soils, *viz.*, those near Tinsukia and Makum, and the one under consideration.

The next group includes Hansara, Dhoedaam and Pabhojan. Most of the samples are light loams comparable with those of the previous table.

Sample.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ignition.	Soil type.
Hansara No. 1 ...	10	28	19	22	15	5·09	2, 4, 3, 5, 1
,, ,, 8 ...	13	37	18	10	17	4·42	2, 3, 5, 1. 4
,, ,, 2 ...	19	30	13	19	12	5·09	2, 4, 1, 3, 5
,, ,, 16 ...	39	28	9	11	9	3·51	1, 2, 4, 3, 5
Dhoedaam No. 22 ...	14	38	12	13	21	4·06	2, 5, 1, 4, 3
,, ,, 11 ...	20	27	15	22	11	4·71	2, 4, 1, 3, 5
,, ...	49	23	6	11	8	3·94	1, 2, 4, 5, 3
Pabhojan No. 6 ...	15	17	22	21	19	4·70	3, 4, 5, 2, 1
,, ,, 24 ...	24	25	17	21	7	4·88	2, 1, 4, 3, 5
,, ,, 8 ...	38	33	7	13	3	4·12	1, 2, 4, 3, 5

In all cases, except Pabhojan No. 6 fine sand is a major fraction. Clay is generally one of the minor fractions.

From Dhaimukhia, Rupai, Deamoolie and Baghjan a selection of loams similar to the above is seen.

Smple.	Coarse sand.	Fn sand.	Silt.	Fine silt.	Clay.	Loss on ignition.	Soil type.
Dhaimukhia ...	10	25	24	18	16	5·20	2, 3, 4, 5, 1
Rupai No. 10 ...	23	19	21	18	14	5·19	1, 3, 2, 4, 5
,, ,, 4 ...	49	21	7	13	6	4·15	1, 2, 4, 3, 5
Deamoolie No. 7 ...	19	37	10	16	13	4·61	2, 1, 4, 5, 3
Baghjan	15	26	19	12	18	8·82	2, 3, 5, 1, 4
,, ...	19	25	32	7	10	5 48	3, 2, 1, 5, 4
,, ...	24	34	16	9	11	4·01	2, 1, 3, 5, 4

From the northern end of the district, analyses are available from Khobang, Talap, Dangri, Dhola and Hakhati. The usual loams are again generally met.

Sample.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ignition.	Soil type.
Khobang No. 16 ...	2	35	28	19	9	5·38	2, 3, 4, 5, 1
,, ,, 7 ...	3	57	24	8	1	5·19	2, 3, 4, 1, 5
,, ,, 21 ...	16	42	12	12	13	5·41	2, 1, 5, 4, 3
,, ,, 24 ...	25	22	13	19	16	5·16	1, 2, 4, 5, 3
,, ,, 30 ...	40	24	13	10	7	4·59	1, 2, 3, 4, 5
Talap *Bheel* ...	8	27	11	13	4	35·17	2, 4, 3, 1, 5
,, No. 11 ...	11	41	19	11	12	4·63	2, 3, 5, 4, 1
,, A	21	24	29	4	17	3·47	3, 2, 1, 5, 4
,, No. 18 ...	32	30	18	5	11	3 84	1, 2, 3, 5, 4
,, ...	40	27	18	4	7	3·94	1, 2, 3, 5, 4
Dangri Tea Seed ...	4	60	9	14	8	3·55	2, 4, 3, 5, 1
,, Dhanbari ...	17	28	22	14	13	4 23	2, 3, 1, 4, 5
,, Raja 10 ...	32	25	17	10	11	4·46	1, 2, 3, 5, 4
Dhola	15	28	22	23	6	6·02	2, 4, 3, 1, 5
Hakhati	2	9	25	38	14	7·12	4, 3, 5, 2, 1
,, ...	10	13	47	8	14	7·29	3, 5, 2, 1, 4

The Hakhati samples are from a new garden put out on an area which appears to be off the Doom Dooma Bank. The soils on part of this grant are alkaline and apparently of more recent deposition than those of the rest of the district. The alkaline patches do not grow tea well.

The *bheel* soil from Talap is interesting. The loss on ignition of this sample, *viz.*, 35.17%, should be noted. Such values are common with Surma Valley *bheel* soils. Where *bheel* patches occur in Assam they may often be used to advantage as a source of top dressing.

The next table shows mechanical analyses from Beesakopee, Sookerating, Budlabetta, Raidang and Samdang.

Sample.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ignition.	Soil type.
Beesakoopee No. 3 ...	9	22	24	21	9	4·96	3, 2, 4, 5, 1
„ „ 8 ...	54	14	9	9	9	4·03	1, 2, 4, 5, 3
Sookerating No. 17 ...	8	21	27	19	18	5·38	3, 2, 4, 5, 1
Budlabetta	28	36	13	12	7	3·51	2, 1, 3, 4, 5
„	38	36	4	10	7	4·47	1, 2, 4, 5, 3
Raidang No. 2 ...	13	27	21	21	13	3·17	2, 4, 3, 1, 5
„ „ 1 F. ...	22	26	14	19	13	4·90	2, 1, 4, 3, 5
Samdang No. 20 ...	9	42	17	19	10	2·28	2, 4, 3, 5, 1
„ „ 24 ...	26	34	12	13	11	3·84	2, 1, 4, 3, 5
„ „ 10 ...	32	19	15	17	14	3·70	1, 2, 4, 3, 5

The last table of the Doom Dooma area includes the three gardens of Bokpara, Bordubi and Koomsong.

Sample.	Coarse sand.	Fine san.	Silt.	Fine silt.	Clay.	Loss on ignition.	Soil type.
Bokpara A 12 ...	2	15	14	32	25	4·54	4, 5, 2, 3, 1
„ 3 B ...	14	35	18	16	12	4·35	2, 3, 4, 1, 5
„ 7 B ...	36	30	10	11	9	3·16	1, 2, 4, 3, 5
Bordubi	15	20	13	6	6	4·12	2, 1, 3, 4, 5
„	19	31	20	12	12	4·66	2, 3, 1, 4, 5
„	32	23	17	11	12	4·17	1, 2, 3, 5, 4
Koomsong	3	33	27	16	17	4·63	2, 3, 5, 4, 1
„	5	39	32	6	13	4·49	2, 3, 5, 4, 1
„	20	48	16	7	9	3·18	2, 1, 3, 5, 4

Margherita.

Although the gardens of Margherita are included in the Doom Dooma Circle the area has such a distinct location that the soils may be conveniently considered as a separate group.

In this area, as in the rest of the Lakhimpur, fine sand usually predominates but fine silt is generally the next most important fraction and coarse sand is very often a minor fraction.

Sample.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ignition.	Soil type.
Powai	29	13	17	19	17	5·78	1, 4, 5, 3, 2
North Bank ...	25	30	13	17	11	4·19	2, 1, 4, 3, 5
Margherita No. 26 ...	2	19	17	23	29	8·35	5, 4, 2, 3, 1
„ „ 10 ...	2	21	19	22	27	7·88	5, 4, 2, 3, 1
Makum, new land ...	16	39	12	17	11	4·10	2, 4, 1, 3, 5
Dirok	4	39	17	20	12	4·19	2, 4, 3, 5, 1
Ledo No. 2 ...	7	37	15	20	15	4·11	2, 4, 3, 5, 1
„	18	19	30	11	16	4·69	3, 2, 1, 5, 4
Pengari G. 2 ...	8	31	23	21	11	4·18	2, 3, 4, 5, 1
„ C3, D7, A1 V, 6	12	31	19	21	11	3·62	2, 4, 3, 1, 5
„ E. 8 ...	21	28	15	21	11	3·90	2, 1, 4, 3, 5

Generally speaking, these soils are stiffer than those in Doom Dooma, and resemble those of Tingri. The Pengari samples are of interest and denote that in the new Burhi Dihing district soils having a texture varying over the same range as is found in other places in Dibrugarh may be expected. The predominant type is somewhat heavier than that found in Doom Dooma.

Tingri.

It is proposed to consider first the Tingri gardens north of the Dehing and to detail those south of this river under a separate section, Naharkatiya.

The Tingri soils resemble in texture those of the Dibrugarh area. The first table deals with gardens located on the western side of the district.

Sample.	Coarse sand.	Fine sand.	Silt	Fine silt.	Clay.	Loss on ignition.	Soil type.
Deohall 2 R. ...	4	40	17	14	19	5·66	2, 5, 3, 4, 1
,, No. 12 ...	14	20	23	19	18	5·36	3, 2, 4, 5, 1
,, ,, 6 ...	45	18	8	11	11	4·94	1, 2, 5, 4, 3
Keyhung	7	25	18	29	15	4·19	2, 4, 3, 5, 1
,, ...	9	24	43	4	13	6·47	3, 2, 5, 1, 4
,, ...	14	47	20	4	8	5·64	2, 3, 1, 5, 4
Hoogrijan P. 5 ...	2	53	22	5	11	5·38	2, 3, 1, 5, 4
,, P. 3 ...	19	36	22	6	10	5·05	2, 3, 5, 4, 1
,, No. 8 ...	28	30	23	3	9	5·23	2, 1, 3, 5, 4
Derial No. 1 ..	7	32	26	12	15	5·92	2, 3, 5, 4, 1
,, ,, 4 ...	9	49	21	6	9	4·44	2, 3, 5, 1, 4
Balijan	21	33	13	14	13	4·69	2, 1, 4, 3, 5
Hattighur	4	44	13	29	15	4·15	2, 4, 5, 3, 1

On the eastern side of the Tingri district the Doom Dooma light loam occurs in many places, and consistently at Rajghurali and Bazaloni. At Jutlibari several section show stiff clays which are easily the heaviest tea soils in the Lakhimpur division north of the Dehing, many of them being as heavy as the clay at Namrup.

Sample.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ignition.	Soil type.
Monkbooshi ...	8	45	25	7	11	4·25	2, 3, 5, 1, 4
,, ...	12	25	25	19	15	5·07	2, 3, 4, 5, 1
Jutlibari A I ...	2	29	37	11	16	4·49	3, 2, 5, 4, 1
,, No. 3 ...	4	11	22	18	37	7·00	5, 3, 4, 2, 1
,, ,, 2 ...	16	22	18	10	28	6·26	5, 2, 3, 1, 4
,, ,, 12 ...	26	34	16	5	15	4·51	2, 1, 3, 5, 4
,, ,, 10 ...	49	17	13	6	11	2·85	1, 2, 3, 5, 4
Zaloni No. 2 ...	7	25	29	15	18	5·04	3, 2, 5, 4, 1
,, ,, 4 ...	10	40	27	7	11	4·05	2, 3, 5, 1, 4
Naholia No. 3 ...	23	31	25	4	13	4·01	2, 3, 1, 5, 4
,, ,, 2 ...	38	19	15	7	13	4·27	1, 2, 3, 5, 4
Tipling No. 6 ...	26	36	20	6	7	3·95	2, 1, 3, 5, 4
,, Puliabari ...	34	16	36	6	2	4·25	3, 1, 2, 4, 5
Rajgarhali	22	32	20	10	10	4·62	2, 1, 3, 4, 5
,, No. 1 ...	40	22	20	5	8	4·25	3, 1, 2, 4, 5
Bazaloni 2 C. ...	28	31	20	9	7	4·05	2, 1, 3, 4, 5
,, 2 A. ...	36	22	21	8	7	4·81	1, 2, 3, 4, 5

Naharkatiya.

The soils of the area will be considered in two tables. The first table includes Langharjan, Jaipur and Kakujan, Tarajan, Namsang (a partial analysis, Hapjan Purbat and Dilli. The last four gardens are all close to the hills, but the other are some distance from them.

Sample.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ignition.	Soil type.
Langharjan ...	37	30	11	13	4	3·76	1, 2, 4, 3, 5
Kakujan No. 4 ...	11	45	20	5	12	4·99	2, 3, 5, 1, 4
,, ...	28	24	18	10	14	5·76	1, 2, 3, 5, 4
,, ...	48	16	13	7	10	5·13	1, 2, 3, 5, 4
Jaipur No. 20 ...	14	29	18	21	13	5·73	2, 4, 3, 1, 5
,, ,, 6 ...	16	34	19	14	11	4·56	2, 3, 1, 4, 5
Tarajan	3	19	40	5	26	6·54	3, 5, 2, 4, 1
,, ...	11	14	41	5	23	5·48	3, 5, 2, 1, 4
Namsang	3	24	24	39		4·56	
Hapjan Purbat No. 4 (Hill)	14	53	11	11	8	3·37	2, 1, 3, 4, 5
Hapjan Purbat No 8 ...	23	36	13	15	9	4·28	2, 1, 4, 3, 5
Dilli B. 12 ...	5	28	40	5	16	4·29	3, 2, 5, 1, 4
,, B. 9	5	38	25	16	9	4·58	2, 3, 4, 5, 1
,, B. 7	23	33	20	6	13	4·04	2, 1, 3, 5, 4

In the above gardens familiar types occur again although few of the light Doom Dooma loams seem to be present. The third sample at Kakujan is a good example of the latter.

In the last table, Balimara, Namrup, Achabam and Teenali are considered. This grouping, like that in other tables, is based on location and not on any particular relationship between the soils. South of the Disam *naddi* heavy banks begin to appear in the plains, away from the hills, the first being that at Namrup, another that at Borhat, followed by the stiff soils of the Sonari district.

Sample.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ignition.	Soil type.
Balimara No. 9 ...	5	30	16	30	13	4·67	4, 2, 3, 5, 1
,, ,, 8 ...	13	40	21	12	9	3·23	2, 3, 1, 4, 5
Namrup ,, 20 ...	1	4	16	40	33	3·95	4, 5, 3, 2, 1
,, ,, 7 ...	1	5	23	36	26	7·00	4, 5, 3, 2, 1
,, ,, 1 ...	1	10	28	33	24	3·45	4, 3, 5, 2, 1
,, ,, 17 ...	1	14	30	33	19	4·92	4, 3, 5, 2, 1
,, ,, 21 ..	1	34	23	22	13	3·97	2, 3, 4, 5, 1
Achabam B. ...	2	26	28	14	21	6·36	3, 2, 5, 4, 1
,, ...	25	24	20	13	13	4·54	1, 2, 3, 5, 4
,, ...	31	28	16	10	10	4·62	1, 2, 3, 5, 4
,, D. ...	36	25	23	4	8	4·43	1, 2, 3, 5, 4
Teen Ali	6	27	22	24	16	3·90	2, 4, 3, 5, 1
,, ...	11	36	16	16	16	4·28	2, 3, 5, 4, 1
,, ...	14	21	12	24	23	5·00	2, 5, 2, 1, 3

The stiff soils shown in this table are capable of yielding good crops, but in order to be kept open and tractable they must be cultivated with care and liberally supplied with organic matter in the form of green crops, cattle manure and cut jungle.

CATERPILLAR PESTS OF THE TEA PLANT, AND OF GREEN MANURE PLANTS AND SHADE TREES IN USE ON TEA ESTATES.

By

E. A. Andrews.

Part I.

On Caterpillars in General.

Dr. Hope, when Chief Scientific Officer of this Department, was wont to tell the story of an applicant for a post in the Entomological Branch. The applicant, having laid claim to the qualifications of an entomologist, was handed a caterpillar, and asked to say what it was, " Sir, it is a worm," came the reply. "What kind of a worm?" "Sir, it is a hairy worm." All of us know better than that, and, indeed, it may have been that the unfortunate applicant knew better too, but was handicapped in describing it, by having to answer in a language not his own. At the same time, how much more do we know? Pressed for further description, we might make an estimate of the size, describe the colour markings, the arrangement of the hairs, the arrangement of the legs, and so on. Asked what else we could tell about it, we might hazard the suggestions that it probably fed on a plant, would turn first into a chrysalis, and eventually into a butterfly or a moth. Thus far does what is known as " General Knowledge " carry us.

For the agriculturist, however, who has to wage continual warfare against caterpillars which take toll of his crops, this is not enough. Without an adequate understanding of the nature, habits, and peculiarities of caterpillars in general, and of those affecting his crops in particular, he is considerably handicapped in organising and prosecuting successful measures for the control of their depredations.

This need has been emphasized during the past two seasons by an increasing number of reports of damage by caterpillar pests, both to tea and to shade trees, and by the contents of some of the communications received.

First, what is a caterpillar? Speaking loosely, one might say that a caterpillar is an insect, and one would not be exactly wrong. Strictly speaking, however, the term caterpillar is one which is applied to one stage in the development of certain types of insect. The recognition of this distinction, and a proper realisation of the part played by this stage in development, and its relation to the other stages, is important.

In the insect world, with its half-million known species, there is great variety of detail in mode of development. At the same time, most species can be placed in one of two well-defined classes according to the general lines along which development proceeds. In the first class development proceeds more or less along the lines to which we are accustomed in the higher animals, that is to say, the insect is born in a form resembling the adult, having similar habits, a similar manner of ingesting food, and so on. In early life, as in the higher mammals and, indeed, in man, the digestive organs are fully developed, but the reproductive organs are not. As growth proceeds, the latter gradually develop further until, at maturity, they become fully developed, and the organism becomes capable of reproducing its kind. In other words, growth and maturation proceed contemporaneously. In the second class of insects this is not the case. Growth and maturation take place at different times. There is first a period set apart for growth, during which there is no development of the reproductive organs. This is followed by a period set apart for transformation, a period during which no food is ingested and there may be a decrease in size; during which the insect changes its form completely; and during which the reproductive organs develop, often so much at the expense of the digestive organs that the latter completely disappear. The next, and last stage, is that of the adult, or perfect insect, a stage during which, and during which only, reproduction of the species takes place, and

in which, in extreme cases, the insect is incapable of feeding, while in others only such food is taken as is necessary to prolong the life of the adult until reproduction has been accomplished.

Caterpillars fall into the second class of insects, which, during development, pass through the following separate and distinct stages :—

1. The egg—laid only by the females of the fourth, last, and adult stage—the period of development of the embryo, a period corresponding to the development of the hen in the egg, and to the period of gestation in mammals.

2. The larva—known in the case of beetles as a grub, in the case of flies as a maggot, and as a caterpillar in the case of butterflies and moths. This stage is the period of growth. Food is ingested in large quantities, the bulk of the body cavity is occupied by well developed digestive organs, and only tiny rudiments of the reproductive organs can be found. The larva (in our case the caterpillar) is neither more nor less than a feeding machine. The whole of the material necessary for the subsequent formation of the perfect insect is elaborated and stored up in this stage. This accumulation of material is manifested externally by an increase in size, to which the insect accommodates itself by a series of moults, at which the outer skin, too small to permit of further expansion, is shed. In certain cases moulting may be accompanied by an external change in form, but in all cases the essential characteristics of a larval stage are retained.

3. The pupa, or chrysalis.—When the necessary amount of reserve material has been accumulated, the caterpillar undergoes a final moult, and turns into a pupa. This is a stage of transformation, during which the reserve material accumulated is utilised

to form the body and various organs of the perfect insect. It is a resting period, one in which no food is ingested, and in which, in most cases, the insect is incapable of movement. For this reason it is often formed in sheltered situations or provided with a protective covering of the nature of a cocoon. It is in this stage that the reproductive organs develop, and that the wings, the organs which facilitate dissemination of the species, are formed.

4. The adult, or perfect insect.—When transformation inside the pupa is completed, the perfect insect bursts forth after rupture of the outer skin of the pupa. In the case of the caterpillar the perfect insect takes the form of a butterfly or moth, capable of reproduction, and of flight, and is the stage responsible for propagating and disseminating the species.

Thus we see that a caterpillar is the feeding stage of a butterfly or moth, an insect whose life-history is divided into four definite periods, during each of which the organism performs certain well-defined functions, necessary to the ultimate development and continued propagation of the species; that unless the respective functions of each stage be carried out, the life-cycle cannot be completed; and that the functions of one stage cannot be carried out by any one of the others. It follows, therefore, that any cause which interferes with the proper development of one stage will have its repercussions during the other stages, and that, in attempting control, if it be found to be easier to deal with, say, the pupal stage than the caterpillar stage, measures calculated to deal with the pest during the former period will probably have far greater value than attempts to destory the caterpillars directly. Thus, an adequate knowledge of the characteristics and habits of the insect in all four stages is of prime importance when devising the best and most economi-

cal means of control. It is to attain this knowledge that attention has been devoted to working out the life histories of the insects subsequently to be described, but as, between different species, in the same stage, the apparent differences in form and habit may be considerable, it is essential, before discussing each species in detail, to envisage the general characteristics common to the various stages in all species.

The egg.—While showing an infinite variety of form, the eggs of all species have one feature in common in that each is enclosed in a horny outer shell very resistant to the action of chemicals. This is a factor of prime importance to the agriculturist, as it affords a natural protection to the eggs against the action of substances which might otherwise be used to destroy them, and means that, as eggs are normally laid on the food plant, the susceptibility of the latter to damage by corrosive substances generally puts the use of anything which would penetrate the shell of the eggs entirely out of court. In certain cases, also, the eggs are laid in irregular clusters and on top of each other, so that many receive additional protection, and in other cases the egg cluster may be protected by a covering of hairs or silk, while in the case of such insects as the faggot and bag worms the eggs are laid inside the faggot or bag originally constructed by the caterpillar. The eggs are very variable in size and appearance in different species, and the size of the egg may be no indication of the size to which the caterpillar will eventually attain. In the case of the looper, for instance, one of the largest of our caterpillar pests, the egg is one of the smallest. As a general rule, the eggs are laid on the part of the food plant to be attacked by the caterpillar—thus, eggs of the looper are laid on the leaves, eggs of bark-borers and borers on the twigs and branches. The number of eggs laid varies greatly, not only between species, but between individuals in the one species. Some species lay a few score only, others close on a thousand, while in the case of the looper moth, for example, the number of eggs laid by different individuals during the present season has varied between 493 and 886.

The caterpillar.—A typical caterpillar can only be described as worm-like in appearance, having, like worms, a long, cylindrical body apparently composed of a series of rings. Here, however, the resemblance ceases. The caterpillar shows the characteristic structure common to all insects, in that the body consists of three distinct regions, the head, in front, the thorax, behind the head, and the abdomen, behind the thorax. The head consists of a hard horny capsule, generally with a polished appearance. On examination it will be seen that the large compound eyes, to be found in the moth or butterfly, are wanting, and that there are, on each side, three small simple eyes. Antennæ, or feelers, are present, but are very small. The moth is furnished with a pair of stout, toothed jaws, or mandibles, eminently suited for biting off pieces of the leaf. The caterpillar is, in fact, a biting insect, and may be contrasted with the adult stage, the butterfly or moth which, if it should feed, is a sucking insect. As a result the food on which the caterpillar lives is quite unsuited to the adult, and thus it happens that the latter may never be found on the bush or plant attacked by the caterpillar, except when eggs are actually being deposited. Behind the prominent jaws is a second smaller pair, difficult to see, and behind the mouth is a small conical protuberance known as the "spinneret." This carries an orific which is the outlet for well-developed silk glands. Caterpillars are adepts at spinning silk, though not all to the same extent, and it plays an important part in the economy of many species. The best-known use of this silk is in the construction of a protective cocoon for the pupa, as in the case of the silkworms of commerce. The faggot and bag worms use it to construct the cases in which they live as caterpillars, attaching pieces of twig or leaves in varying degree to strengthen them. Leaf-rolling caterpillars roll up the leaves by means of this silk. A thread is affixed to the leaf by each end. On drying this contracts a little, bringing the two parts of the leaf closer together. A second thread is then attached. This, by contraction in drying, draws the two parts of the leaf still closer together, and so the process goes on. The silk is also made use of in scaling smooth vertical or overhanging

surfaces which would otherwise be impassable. A silken thread is attached to the surface at each end. To this the caterpillar clings, and, extending forward as far as possible, places another thread. It can then move forward to this one, and so make progress. A futher use of the silk is to enable the caterpillar to keep its bearings and retrace its steps should there be any necessity. This is done by spinning a continuous strand of silk as it creeps along, so that the path it has traversed is defined by a fine silk thread, by following which the caterpillar can return to its original location. This habit is especially characteristic of caterpillars which live gregariously, and are in the habit of congregating together during periods of rest between feeding, such as the cluster caterpillar. Finally, caterpillars which live on high trees, but form the pupae in the ground, let themselves down from the tree by a silken thread attached to the tree at one end, by lengthening which they gradually descend. This is a point to remember when collecting pupae of such insects attacking shade trees. The spot around the base of the tree trunk is the last place to look for the pupae, as most of the caterpillars, letting themselves down from wide-spreading branches, land among the tea bushes away from the trunk.

Behind the head come three segments, each of which bears a pair of jointed legs ending in a pointed claw. These three segments constitute the thorax. On each side of the first segment is an orifice which forms one of the openings of the respiratory system. This region of the body corresponds to the corresponding region in the adult, in which the two hinder segments each bear a pair of wings. The three pairs of legs are the true legs, corresponding with those of the adult, and quite distinct from the other legs which may be found on the caterpillar, which are not true legs at all.

The hindmost region of the body is the abdomen, which, as its name suggests, contains the bulk of the digestive organs of the body, and in which the bulk of the reserve food is stored in the form of fat. This region consists of ten segments, of which

the ninth is not easily seen without dissection, and of which the first eight bear on each side orifices, connected with the respiratory system, of similar function to those on the first segment of the thorax. On the underside of certain segments of the abdomen, the third, fourth, fifth and sixth, may be borne unjointed, fleshy legs, the false legs, abdominal legs, or pro-legs, which help to support the cumbrous body, and the last segment of all carries a pair of similar, but specially developed legs often known as claspers. Deviations from this arrangement, however, are found. In the looper caterpillar there are no pro-legs on the third, fourth and fifth abdominal segments; in the semi-looper caterpillars only segments five and six are provided with functional pro-legs; while in caterpillars such as the lobster caterpillar the hindmost pair of legs is represented by filamentous appendages. At the hind end of the body, on the last segment, is the anal opening.

The pupa, or chrysalis.—The last act of the fullgrown caterpillar is to make the necessary preparations for the well-being of the pupal stage. The first stage in these preparations is the choice of a suitable spot, and some species travel considerable distances in the search. In cases in which the pupa is naked, as in the looper, the final moult and formation of the pupa will then take place. In other species, such as the bunch caterpillar, in which a protective cocoon surrounds the pupa, this is constructed before the final moult takes place. The protective cocoon takes many different forms, as will appear in the more detailed description of the various species. When the cocoon is completed, the final moult takes place, the larval skin splits, and there wriggles forth a form quite different from the caterpillar, and bearing a great resemblance, except in colour, to the moth. The head now bears large compound eyes, long and well developed antennæ, and in sime cases a well-developed sucking beak, or proboscis. There are longer legs, but only six, two on each of the thoracic segments, and two pairs of wings have begun to grow from the two hinder segments of the same part of the body. The abdomen has shortened compared with

that of the caterpillar, but the division into rings or segments still persists. As, or soon after, the pupa emerges, the various appendages, proboscis, antennæ, and legs, bend over and become arranged symmetrically along the under surface of the body, while the wings lie flat against the back and sides. Then a sort of varnish exudes all over the body, which glues all the appendages in position. This is characteristic of the pupa of the caterpillar, and enables one to distinguish such from those of beetles and other insects, in which the various appendages are not glued down to the body of the pupa. Dissection of the pupa at this stage shows it to be filled mainly with a milky fluid, in which only rudiments of the various organs of the body are to be seen. In other words, the internal organs of the insect are being entirely reconstructed. Under these circumstances, as can readily be imagined, the insect does not move about, though in certain species there is some power of motion. The pupa of the sandwich caterpillar, for example, appears always to retain the power of moving the abdomen up and down and from side to side. Just before emergence of the adult, however, a certain power of motion is common. The male pupa of the faggot worm, for example, moves partly out of the case to permit of the unimpeded emergence of the moth.

The pupal stage is one in which the insect is peculiarly susceptible to environmental changes, the more so as it is unable to change its locality and so modify their effect. As a result it is common to find great variation in the time occupied in this stage, and, in the case of the majority of the insects with which we shall deal, it is in this stage that the delay in development necessary to tide the insect over the dry cold weather period, during which the growth of the food plant is practically at a standstill, occurs. This fact makes possible the very efficient control which can be exercised, over such caterpillar pests as form the pupa in the soil, by mere collection while forking is being carried on in the cold weather. The time factor, which plays a prominent part in reducing the chances of successful control during the other stages, is of less importance then. The

pupae have no power of changing location; there is no need for hurry; the coolies, forking their given task, augment their earnings in proportion to the thoroughness with which they prosecute the search each day, and soon realise the fact. There is no expenditure on apparatus or chemicals, no disorganisation of the routine work of the estate, no need for any supervision beyond that ordinarily given to the forking. Moreover, experience has proved that if it be "featured," as the Americans would say, as part of the cold weather programme every year, other measures are seldom or never necessary.

An interesting point with regard to this extension of the pupal period during the cold weather is that, although possibly controlled to some extent by climatic conditions, adaptation comes into it too. Plucking of tea generally ceases, in this district, at the end of November, and by February the bushes are coming away again. The leaf remains on the shade trees, however, till January, and the trees are bare until the end of March or early April. It is noticeable that in the case of tea pests the last brood of the year has pupated by the end of December, while in the case of pests of the shade trees this does not occur till the end of January or early February. Similarly, the times of emergence of the moths coincide with the coming into leaf of their respective food plants. The practical application of this observation lies in the fact that, in sections where caterpillar damage to the tea has been most prominent, collection during the earlier part of the cold weather is indicated, while where shade trees have suffered considerably collection during the back end of the cold weather gives the better results.

In the case of caterpillars which form their pupae on the bushes much good is done by destroying all prunings, either by burying or burning, while the strong washes recommended for application to pruned bushes have a certain amount of benefit. It should also be remembered that if rubbish, such as dead leaves, etc., be allowed to accumulate in the bushes, many types of caterpillar will crawl amongst it to form the chrysalis, whereas, if there be no rubbish in the bushes, they will go down to the

dead leaves and rubbish on the surface of the soil, where they are in danger from the hoe and the forking people.

The adult.—At the end of the pupal period the pupal case splits open, and the adult form emerges as a butterfly or moth as the case may be. At the outset it may be stated that so far as this series of notes is concerned it will generally be a moth. It is a curious fact, and one worthy of note, that, so far as is at present known, there is no butterfly pest of tea in North-East India. In 1914* the writer recorded the fact of damage to tea by caterpillars of the butterfly *Delias aglaia* L. The caterpillars did eat the tea, and were bred to maturity on tea, but it is now known that its occurrence on tea is entirely accidental. Its normal food is the wild mistletoe (Assamese "rogamulla." *Loranthus* sp.), and it is only found on tea when a branch of the former, with caterpillars on it, has been blown down by the wind, or otherwise detached. In Watt & Mann† the butterfly *Pareba vesta* F. is recorded as a minor pest of tea in Assam and Darjeeling, but no record of even minor damage has occurred since. There are, however, a few butterfly pests of green manures and shade trees.

After emergence the adult insect rests while the wings, which are at first crumpled and useless, expand and straighten out, after which it flies away. Since the majority of our pests are caterpillars of moths, which, as a rule, fly about very little in the day-time, little is seen of them on the tea gardens. The looper moth, which rests on the trunks of the shade trees, and the red slug moth, which is conspicuously coloured and flies about a good deal in the day-time, are well-known to most tea planters, but the rest, being, for the most part, inconspicuous, and flying, as they do, after dusk, are not often observed. For this reason the planter is seldom in a position to judge beforehand whether he may expect an unusually severe attack of the caterpillars or not, and as, in all the cases with which we shall deal, the eggs

*I.T.A. Scientific Department, Quarterly Journal, Pt. III, 1914, p. 113.

†"Pests and Blight of the Tea Plant," 2nd edition, 1903, p. 179.

are far from conspicuous, his first intimation is obtained, as explained above, when the caterpillars are fairly well developed.

Control methods against the adult stages of the moths whose caterpillars do damage on tea estates are in most cases wanting. An inconspicuous insect which flies only after dusk, and then possibly fairly high in the air for most of the time, can hardly be dealt with unless he can be enticed to emerge from the obscurity in which he lives. Light traps, attractive baits, etc., are means to that end in the case of some insects, but have not proved efficient against the pests in tea. Moreover, none of our moths live very long—a few days at most under insectary conditions, and probably not much longer in the open, for death occurs soon after the eggs have been deposited, and the time factor is therefore a considerable obstacle.

In subsequent articles the individual caterpillar pests of the tea plant, shade trees, and green manures will be dealt with in detail.

TEA IN NORTH-EAST INDIA,

Part II.

by

P. H. Carpenter.

The climate.

The predominating factor which has made Assam such a successful tea-growing country is its climate. The best tea grows on practically any type of soil from the peats or *bheels* of the Surma Valley and the heavy clays of the Dooars to the light, poor sands found near the Brahmaputra, but, in order that it shall thrive, it must have a warm, moist climate with no long droughts. This first necessity was recognized many years ago and the following extract, taken from the *Tea Cyclopædia* published in 1881, is of interest in this connection.

" Tea, it may be premised, will grow almost anywhere, but not very many climates will enable it to pay.

" To describe the best climate in two words, we point confidently to Eastern Bengal; indeed, the judgment of a considerable portion of the Indian public interested in tea has long since pronounced the same decision. A hot, moist climate, where the thermometer in the shade never exceeds 95° F.; never falls below 55° F.; where the rainfall yearly aggregates 100 to 130 inches; where there is never any long drought, but where rain falls at reasonable intervals all the year round; where heavy dews are frequent; where morning fogs are not uncommon; where the sun shines hot in an atmosphere perfectly free from dust; where at no season can a breath of hot wind be felt; where light, penetrating rain is more common than furious downpours; where the effect of the entire climate is essentially enervating to man, and takes much out of him; these are the conditions that constitute, in our opinion, good climate for tea, and where it is wise, anywhere, to make tea gardens. Fever and tea go together.

It may be a painful fact for tea planters, but it is no less true. No highly successful tea district can ever be a healthy one."

Eastern Bengal probably refers to Cachar, for the temperatures recorded in the Assam Valley fall considerably below 55°F. The statement that fever and tea go together fortunately no longer holds good.

In order to understand the climate of North-East India and to realize how conditions in that area differ from those in Ceylon and South India, the other two big British tea areas, it is necessary to have some idea of the monsoon changes.

Broadly speaking, there are two sets of winds blowing steadily across the earth, the trades and the anti-trades. The trade-winds blow from the north and south to the Equator, but, owing to the revolution of the earth, the general direction is from the north-east and south-east. In the temperate zones the complements of these winds, the anti-trades, are met blowing from a south-westerly direction in the northern and a north-westerly direction in the southern hemisphere. Between these two sets of winds are two belts of calm where are found the deserts and Sargasso seas.

But for the land mass of Central Asia the peninsula portion of India would be in the course of a steady trade wind from the north-east, and Northern India would be included in the chain of deserts formed by Sahara, Arabia, Persia and the Thar desert. As it is, the land mass of Asia warms up in the summer months and there follows a general flow of air from the southern latitudes to take the place of the air rising from the Asiatic plateau. Eventually, this air flow becomes strong enough to overcome the north-east trade wind and then the south-west monsoon begins to blow. The strength of the monsoon varies with each season, and although the ultimate cause of this variation has not been decided, it depends in part, at any rate, on the oscillations of the two winds which are pitted against each other.

West of Ceylon the monsoon current splits into two main components, one running up the east coast of Africa and the other round the Bay of Bengal.

The current moving up the Africa Coast sheds copious rainfall on the Abyssinian plateau which floods the Nile and enables the Egyptian crops to flourish in a permanently cloudless sky. After meeting the Abyssinian plateau, the current makes an eastward turn passing Cape Gardafui and the island of Socotra and, having lost practically all its northerly component, reaches Bombay from almost due west. The rainfall at Bombay is 150 inches, but inland it decreases quickly, and Poona has an average of under 30 inches, although further from the coast there is an increase again. Arabia, Persia and Sind miss the monsoon, and Karachi has a rainfall of under 10 inches.

The Bengal current is weaker than the African one. During its movement round the Bay, it serves the southern part of Burma and then comes to Bengal. Both currents are influenced by a depression which occurs in part of Sind, and Rajputana.

Towards the end of the season, the Bengal current is caught up in cyclones which whirl it across India, and the rainfall brought in this manner has a great influence on the winter crops.

Before the summer is finished, the attraction towards Central Asia begins to weaken, and by the autumn the air flow definitely begins to turn southward, and the cloud canopy is withdrawn from Northern India. The north-east trade winds, previously extinguished by the monsoon, are now reinforced by cold dry winds blowing from the desert of Tibet which warm up as they cross the Bay of Bengal, and pick up moisture to be deposited later on the southern half of Madras.

From the above brief account of the general air movements over India, it will be understood that Assam and the north-east corner are out of the track of the monsoon, yet on account of the general air drift towards the Tibetan plateau, there is a steady flow of moist air into this area. Furthermore, the Himalayan barrier and the funnel shape of the Surma and Brahmaputra valleys ensure that clouds, when they once enter the country, are shepherded round the hills till they are deposited as rain.

Because of this, Assam is one of the permanently green provinces in a continent where conditions are, on the whole, arid.

It will also be seen that the western side of Ceylon and South India are served mainly by the south-west monsoon which a week or two later arrives, by a different route, in Assam. The eastern side of Ceylon and South India are served mainly by the north-east monsoon which blows dry over North-East India before reaching the Bay of Bengal.

The rainfall tables below illustrate the variation in rainfall in the three districts. The first table shows the rainfall in typical areas of Ceylon.

Average rainfall in Ceylon.

	Colombo.	Kandy.	Nuwara Eliya.	Badulla.
	In.	In.	In.	In.
January	3·36	5·22	5·65	9·71
February	1·84	2·23	2·03	3·02
March	4·30	3·86	5·11	4·34
April	9·67	6·78	5·66	7·46
May	10·73	5·43	6·64	4·45
June	7·20	9·64	12·85	2·29
July	4·48	7·50	12·07	1·99
August	3·14	5·69	7·91	3·22
September	4·73	5·93	8·29	3·37
October	13·44	11·80	11·13	9·88
November	11·59	10·57	9·00	10·45
December	5·11	9·12	8·57	12·43
TOTAL ...	79·59	83·77	93·12	72·01

At Colombo both monsoons are distinctly marked with dry periods between them. Kandy, occupying a central position in the island and not cut off on either side by high mountains, gets a more evenly distributed rainfall in addition to generous precipitations from both monsoons. Nuwara Eliya is similarly treated. Badulla, in Uva, is on the east side of the rain divide and receives most of its rain from the north-east monsoon.

In South India, the extremes of rainfall are shown by Madras on the Coromandel Coast, facing the Bay of Bengal, and at Cannanore, on the Malabar Coast, facing the Arabian Sea. Towards the west coast are the tea districts. The Nilgiri District is the one farthest from the sea, and the Anamalais and Travancore face the weather. These points are illustrated in the table below :—

Average rainfall in South India.

	Madras.	Cannanore.	Nilgiri.	Anamalais.	Travancore.
	In.	In.	In.	In.	In.
January	1·14	0·25	2·38	0·40	0·41
February	0·30	0·26	2·32	0·12	1·47
March	0·34	0·18	1·94	0·21	0·44
April	0·63	2·15	4·12	3·48	2·52
May	1·84	7·78	6·00	3·99	11·77
June	1·97	38·22	4·08	28·56	48·67
July	3·84	35·07	4·74	83·18	74·33
August	4·54	18·83	4·33	23·70	40·47
September	4·86	8·63	6·63	17·34	26·47
October	11·15	7·95	14·35	8·17	19·69
November	13·61	3·67	10·16	3·35	23·85
December	5·35	0·61	4·30	0·33	0·51
TOTAL ...	49·57	123·50	66·35	172·83	250·31

In Assam, the rainfall varies over a wide range. At Cherrapunji, one of the wettest spots on earth, it averages 381 inches with a maximum record of 905 inches. In Silchar it is 122 inches, in North Lakhimpur it is more than 160 inches, and at Dibrugarh 122 inches. In the rain shadows of the Mikir Hills in the Golaghat District, it drops to about 50 inches.

At Tocklai the average for the past nine years is 82 inches-although there has been a wide variation on either side of this value. From 1917 to 1926 the values recorded have been 97, 75, 68, 82, 74, 101, 66, 86, and 75 inches. The table below shows the rainfall at various stations in North-East India.

Average rainfall in North-East India.

	Upper Assam (Doom Dooma).	Middle Assam (Tocklai).	Surma Vally (Silchar).	Dooars (Sylee).
	In.	In.	In.	In.
January	1·47	0·95	0·64	0·47
February	2·79	1·35	2·32	0·74
March	5·93	3·59	7·99	1·12
April	10·69	7·89	13·56	3·99
May	10·63	9·66	15·72	11·09
June	15·80	12·43	20·39	33·43
July	19·58	17·04	19·98	44·5
August	16·27	13·01	18·69	28.21
September	10·58	10·11	13·95	28·67
October	4·49	4·47	6·40	7.49
November	0·64	0·92	1·31	0·98
December	0·43	0·37	0·54	0·19
TOTAL ...	99·30	81·79	121·43	164·48

Although rainfall is the chief factor in determining the suitability or otherwise of a district in India for tea, the distribution of the rainfall is an important factor. In addition to this, humidity plays a dominant part. In Northern India generally, the year may be divided into three seasons, the cold dry season lasting from November to February, the hot dry season lasting from March to May, and the hot, wet season of the monsoon lasting from June to October. The tea bush is an evergreen, designed by nature to grow in a warm, humid climate; and if the hot dry season is well marked as it generally is in Northern India, then tea will not flourish. In the outlying districts of North-East India like South Sylhet and the southern part of Jalpaiguri district, although the rainfall in the spring compares favourably or is even greater than that in the Brahmaputra Valley, the humidity is low and the bushes stop flushing.

The table below shows the rainfall at Habiganj in South Sylhet where the tea goes *banjhi* in the spring. At the town of Jalpaiguri, which is about 40 miles south of the Himalayan foothills, the tea acts similarly and is sometimes pruned in the spring. At Ranchi, in Orissa, the early drought is so severe that the bushes are sometimes completely defoliated. At Dehra

Dun the same thing happens and plucking stops in May and June until the monsoon arrives.

	Habiganj (Sylhet).	Jalpaiguri.	Ranchi.	Dehra Dun.
	In.	In.	In.	In.
January	0·45	0·30	0·63	2·19
February	1·24	0·66	1·24	2 49
March	4·53	1·36	1·10	1·46
April	9·08	3·73	0·80	0·78
May	15·12	11·07	2·33	1·57
June	19·74	23·73	9·00	8·29
July	15·82	31·28	14·46	24·33
August	14·23	25·04	13·61	25·68
September	11·78	19·94	8·23	9·30
October	5·99	4·90	2·79	0·29
November	0·83	0·20	0·37	0·92
December	0·27	0·11	0·16	0·67
TOTAL ...	99·29	122·32	54·72	77·97

In Assam and the Dooars the advance of the monsoon is marked by a rise in temperature and humidity. During the cold weather a difference as great as 30° F. may be registered between the maximum and minimum temperatures, but after the monsoon has broken, the difference is usually about 10° F. The table below shows the maximum and minimum temperatures of typical stations.

	Silchar (Surma Valley)		Tocklai (Assam Valley)		Dooars (Kalchini).		Darjeeling.	
	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
January	78	52	70	50	75	46	47	35
February	81	56	73	53	76	49	48	36
March	86	63	79	60	84	55	51	42
April	89	69	83	67	87	66	62	49
May	89	73	86	72	89	70	64	53
June	89	76	89	76	88	74	65	56
July	90	77	90	78	89	75	66	58
August	90	77	89	78	89	75	66	57
September	90	76	88	76	99	74	64	56
October	89	72	85	71	88	66	61	50
November	85	64	78	60	84	56	54	42
December	80	55	72	51	78	47	49	37

In Ceylon and South India the seasonal differences are very small and the mean temperature shows practically no change. At Ratnapura in the low-lying tea district of Ceylon, the annual mean is 80°F., at Kandy (1,654 feet) it is 74°F., at Nuwara Eliya (6,188 feet) it is 59°F., and at Badulla (2,225 feet), in Uva, it is 74°F. At Kotagiri, in the Nilgiri district of South India the annual mean is 73°F.

The absolute humidity, as measured at Tocklai, shows a value of about 0.4 to 0.5 inch mercury in January. In March or April it begins to rise and reaches a value varying from 0.6 to 0.8 inch. With the break of the monsoon there is another rise to about 0.90 inch at which figure it is roughly maintained till September or October when it steadily falls, till in December it is back to 0.4 to 0.5 inch. Humidity controls our tea crop.

The wind direction is either north-east whence it blows cold and dry or south west from which direction it blows warm and moist. During the monsoon there is a general air drift from the south-west, although the ground wind and rainfall may come from other directions, depending largely on the topography of the particular district. The early months of the year are the most windy, and during March, April and May hurricanes often blow, sometimes with hail. The latter contingency is a real danger, for a hail storm may well strip a whole area of tea. Most gardens in districts liable to hail insure against such damage.

Only 3 years' wind records are available for Tocklai and the average of these is given below and illustrates roughly the change in rate of air drift.

Daily wind mileage at Tocklai.

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Average 3 years	26	40	55	74	42	43	43	41	35	25	20	16

The amount of sunshine is an important factor influencing, as it does to some extent, the tannin content of the leaf, and

also having an effect on the reproduction and attack of certain fungus diseases.

Sunshine is, in part, a complement to rainfall and varies to some extent inversely as the latter. The average sunshine at Tocklai recorded during the past 9 years is as follows :—

Average daily sunshine in hours at Tocklai.

Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
5·3	5·7	5·7	4·9	4·7	4·2	4·0	4·4	3·9	5·8	5·6	5·2

The decrease in sunshine with the coming of the monsoon is well marked. July is the wettest month, and August on the average wetter than September. At times, however, long sunny spells are experienced in August and these periods raise the sunshine average.

In the Dooars the sunshine average generally seems to be smaller than that in Assam. Only four years' record over the mid-season are available and these show a wide variation. The table below shows the values for 1925 and 1926.

Hours of sunshine per mensem at Sylee (Dooars).

	April	May	June	July	August	September
1925	118	101	124	94	96	86
1926	180	147	91	68	127	170
1927	217	216	144	114	149	144
1928	109	169	91	111	123	133

Much less sunshine is recorded in the Dooars during the monsoon than in Assam as the table below shows.

Hours of sunshine per mensem at Tocklai.

	April	May	June	July	August	September
1925	105	102	156	158	136	117
1926	177	170	131	112	149	124
1927	191	193	171	147	154	138
1928	230	161	120	192	167	142

A sunny season, especially a sunny spring in the Dooars, is considered to be associated with light tea mosquito (*Helopeltis*) attack. No sunshine records other than those quoted above are available for the Dooars, but it seems probable that what is regarded as a sunny season in the Dooars may show a record of hours of sunshine no greater than is the general average in Assam. In Sylhet, where, from experience only, it is assumed that the hours of sunshine approach those in Assam. A sunny start to the year is thought by many to mean a heavy mosquito attack later. A sunny start means a severe drought usually, and a serious weakening of the bushes.

Until more records are available, little progress will be made in correlating pest and blight attack and sunshine.

As previously mentioned, humidity is the main factor controlling the tea crop. In the Brahmaputra Valley the bushes are tipped in March or April after the spring flush. The first real flush comes in May and the second in June. The big months are July, August, September, and during these months 50—60 per cent. of the crop is gathered. The half season occurs about the middle of August. October is a good month varying greatly, and November gives one or two good pluckings if the rains hold good. From December till the spring tipping, the bushes are not plucked. Our heavy flushing period corresponds with the combination of high temperatures and humidity (both relative and absolute) which is characteristic of monsoon conditions.

In Ceylon, as in India, the bushes begin to flush, without the stimulation due to plucking, with the spring rains. The heaviest flushing months all over the Ceylon districts, both in the south-west and the north-east monsoon areas are March, April and May. During the first six months of the year many estates make two-thirds of their crop. In June, July and August, during which time the monsoon blows hard and the rain falls in torrents, the crop is poor. After August the crop increases to a second maximum in November. December,

January and February are again poor months in the south-west area although in Uva, November, December and January are good months owing to the north-east monsoon rain.

In South India plucking generally continues throughout the year although during the height of the monsoon the bushes may close. There are two big flushing periods, the first being April-May when about 25 per cent. of the total crop is made, and the second, September to December, when 35—40 per cent. of the crop is made. Great variation in cropping intensity is, however, shown in different districts.

(*To be continued.*)